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QUALITY, VERTICAL INTEGRATION AND ADAPTABILITY*

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Abstract

As global competition increasingly focuses on product quality, firms need to ensure the quality of their inputs. A central question is then which organizational structure best enables them to achieve this objective. Numerous papers have found that firms that produce higher quality are more likely to integrate with their suppliers. However, their focus so far has been placed on quality unobservability as the driver of integration. In this paper, we confirm the empirical relationship between quality and vertical integration but uncover an alternative mechanism in a set up where quality unobservability is not relevant: a stronger need for high quality producers to adapt efficiently to uncertain events. Based on a survey of 688 Spanish wineries and using the probability of hail as a proxy measure of uncertainty and need for adaptation, we find that the relationship between product quality and vertical integration is stronger for wineries in locations subject to more climatic uncertainty. In those cases, vertical integration comes out as an organizational form that provides high quality producers with more adaptability to preserve input quality in response to unforseen events.
Keywords: Vertical Integration, Quality, Adaptation

JEL Codes: L14, L15, L22

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I Introduction

Competition in international markets increasingly focuses on quality, which imposes on firms the need to ensure the quality of the inputs they buy (Amodio & Martinez-Carrasco, 2018; Atkin et al., 2017; Bas & Strauss-Kahn, 2014; Bastos et al., 2018; Hallak & Sivadasan, 2013; Halpern et al., 2015; Kugler & Verhoogen, 2012). Also, firms need to comply with an increasing number of quality requirements to be granted market access to foreign countries.[1] A key question is then which organizational structure may be more conducive to successfully facing those challenges. In this paper, we explore the role of vertical integration as an organizational device to ensure the provision of quality inputs.

Several papers have posited that firms vertically integrate to achieve higher levels of product quality (Fernández-Olmos et al., 2009; Hansman et al., 2020; Hennessy, 1996; Martinez, 2002; Vetter & Karantininis, 2002). Likewise, a more specific literature focused on agri-food products highlights a trend towards concentration following the proliferation of public-private regulations in international food standards (e.g., Henson & Reardon 2005; Reardon et al. 2009, 1999; Swinnen 2014). All of these papers point to difficulties to observe or measure input quality as the underlying mechanism behind the observed relationship between product quality and vertical integration.

While the focus of this literature has been placed so far on imperfect observability, other mechanisms highlighted by the more general literature on vertical integration could also lead firms to vertically integrate in their pursuit of quality. Prominent among them is "adaptability" (Simon, 1951; Williamson, 1971, 1975). The need to adapt in response to unforeseen events is especially important in climate-dependent agricultural-based industries subject to high uncertainty (e.g., olive oil, asparagus, pepper), industries subject to abrupt changes in demand (e.g., clothing[2]), or industry heavily reliant on new technologies such as video games. Under lock-in relationships, even temporal ones (Tadelis, 2002), the need for adaptive, sequential decision-making may imply high renegotiation costs ex-post and thus justify vertical integration as a means of preserving flexibility to avoid those costs (see Bajari & Tadelis 2001; Gibbons 2005; Januszewski Forbes & Lederman 2009). Notwithstanding the theoretical appeal of this driver of vertical integration, its empirical relevance in

[1] Melo et al. (2014); OECD (2007); World Bank (2005).
[2] See Richardson (1996) and Woodruff (2002).

the specific context of the literature relating quality to vertical integration has yet not been explored. In this paper, using a survey of 688 wineries in Spain we find support for the notion that adaptability is a significant driver of the observed relationship between quality and vertical integration.

The wine industry is ideal for our purposes. First, unobservability of input quality is not particularly relevant in this industry since the main quality parameters (PH, sugar, acidity, and sanity) can be checked by just tasting the grapes. Furthermore, more elaborated tests on those and other parameters are inexpensive to conduct and are widely available for nearly every winery. Second, grape-growing is heavily dependent on climate. The variability of climate creates a highly uncertain environment for the transaction of grapes, hindering the possibility of writing complete contracts that contemplate what to do in response to each possible contingency. Moreover, climatic uncertainty is particularly important for higher-quality grapes, as the loss of quality in the face of a negative climatic event can be dramatic if costly responses are not rapidly taken. Finally, the basic necessary condition that the quality of grapes have a substantial impact—in this case crucial—on the quality of wines is satisfied (Villanueva et al., forthcoming).

To perform our empirical inquiry, we use a survey of 688 Spanish wineries distributed among the 68 appellations of origin that exist in Spain,[3] and complement it with qualitative information obtained from interviewing winemakers located in Spain, Argentina, and Switzerland. The first step is to measure quality. For this purpose, we construct a quality index that is based on the adoption of production processes, both in the vineyard and at the winery, in pursuit of wine attributes linked to their organoleptic power (i.e., physical, sensorial quality). We call this index "pursued quality". As opposed to Crozet et al. (2012), who rely on experts' rankings, we choose a measure linked to physical attributes of wines as they are more tightly connected to the quality of grapes, which are what wineries and grape growers transact upon.

The second step is to find variability in the firms' need for adaptation. Since numerous climatic events force adaptations but many of them are not quantifiable, we focus on one of the most feared events in the wine industry: hail (Cagnetti et al., 2013; Wilson, 1998). Following Januszewski Forbes & Lederman (2009) in their use of meteorological uncertainty as a measure of need for adaptation, based on data collected by 81 meteorological stations distributed around Spain we construct a

[3] Appellations of origin denote specific geographic regions whose wineries comply with certain standards that ensure obtaining products with singular attributes. See Villanueva et al. (forthcoming) and section II for further details.

variable that captures the number of average hail days affecting each winery during the blossoming phase. The identifying assumption is that areas with higher average hail days have a greater need for adaptation.

We first verify that the relationship between vertical integration and product quality already found in the literature also holds in our sample of Spanish wineries. Specifically, we find that wineries pursuing higher quality tend to use a higher percentage of own-grown grapes (a one standard deviation increase in pursued quality is associated with a 3.9 p.p. increase in the use of own grapes). Then, we go on to test whether the adaptability is a significant driver of this relationship. We find that this is indeed the case. The pursuit of quality is a stronger driver of vertical integration in wineries located in areas characterized by a higher need for adaptation. This result is robust to different subsamples and to a more restrictive definition of quality. Evaluated at the first quartile of the need-for-adaptation variable, one standard deviation in quality implies a 2.9 p.p. increase in the share of own grapes used in wine production; evaluated at the third quartile, it implies an increase of 5.2 percentage points in this share.

To the best of our knowledge, this paper is the first to show that adaptability is a relevant driver of the observed relationship between product quality and vertical integration. Thus, it contributes to that literature by complementing the current sole focus on quality unobservability to explain that relationship. More generally, the paper also contributes to a vast literature on firms' make or buy decisions.[4] Despite adaptation being one of the four main "theories of the firm" (Gibbons 2005), it has received little empirical scrutiny so far. A salient exception is Januszewski Forbes & Lederman (2009), who find that airlines with hubs in city pairs whose airport locations are subject to more climatic uncertainty –and thus require more adaptations–are more likely to vertically integrate with regional airlines operating in those airports. Also, Forbes & Lederman (2010) find that vertically integrated airlines perform better than non-integrated ones–in terms of shorter delay times–particularly in geographical locations with more uncertain weather. While our paper also exploits geographical variation in climatic uncertainty as a measure of adaptation needs, our focus is on the differential impact of this variation on the incentives to integrate according to product quality. In this regard, we show that the impact of climatic uncertainty is stronger for high quality goods,

[4] See Williamson 2002 and Gibbons 2005 for a review of the main theories and Lafontaine & Slade 2007 for a review of the empiric evidence.

as expected since they require more adaptability to maintain quality in the face of adverse climatic events (see discussion in section V), their greater complexity hinders the possibility of contracting on contingent events (Bajari & Tadelis 2001), and the costs of not undertaking the required adaptations are higher due to greater losses in product value.[5]

From a policy perspective, this finding informs the design of public policies aimed at balancing the objective of promoting quality production with its potential negative effects on economic concentration. Among those policies are regulations limiting land ownership, policies aimed at improving the contractual environment, and policies aimed at lowering entry costs, e.g. by improving access to finance (Acemoglu et al., 2009; Macchiavello, 2012). Also, as international trade increasingly demands quality products, this finding could help countries design their international integration policies by shedding light on firm strategies to ensure the provision of quality inputs (Bastos et al., 2018; Fieler et al., 2018; Halpern et al., 2015; Kugler & Verhoogen, 2012).

The rest of the paper is organized as follows: Section II describes the wine industry and our survey data. Section III investigates the relationship between quality and vertical integration. Section IV discusses theoretically the adaptability mechanism hypotesized to be behind this relationship. Section V tests this mechanism empirically and confirms its empirical relevance. Section VI concludes.

II The Wine Industry

In this section, we provide context for our empirical study by briefly describing some relevant features of the Spanish wine industry and the main features of our survey data.

II.A The Spanish wine industry

The wine industry is one of the most important industries in Spain. It contributes around 24 billion euros in annual revenue (equivalent to 2.2% of gross value added) and generates nearly 430,000 jobs (2.4% of total employment). With a production volume of approximately 40 million hectoliters, Spain is the third largest producer in the world. Spain is also a traditional exporter that reaches 189 countries and enjoys worldwide recognition for its wines. It is the largest volume exporter (2300

[5] Januszewski Forbes & Lederman (2009) also show that vertical integration is more likely in cases where the costs of failure to adapt are higher.

million liters) and the third largest value exporter (2900 million euros).

The wine sector is composed of around 4100 wineries distributed across the Spanish territory. The majority of wineries (approximately 3700) belong to one of 70 Appellations of Origin (AO, henceforth) that exist in Spain. AO are delimited areas whose wines possess idiosyncratic characteristics that distinguish them from other wines and thus can garner additional value in the market. Wineries that wish their bottles to be sold under an AO seal need to comply with a variety of product and process requirements mandated by the corresponding AO regulatory body. Among those rules, for example, are the grape varieties that can be used, the irrigation and thinning systems allowed, and limits to plantation density and production per hectare. AO wineries accounted for 48% of Spanish wine production during the 2020/21 agricultural season and 58% of its export value in 2020 (CECRV, 2023).[6] To a large extent, the rest of the wineries produce table wine, which is considered of lower quality and is typically priced in a lower price range.

II.B Data sources

Our sample consists exclusively of wineries that belong to an AO.[7] As every AO Regulatory Council keeps an updated file of their wineries, a list was first obtained of the population of 3661 wineries under the 70 AO registered in Spain in 2021.[8] To collect the data, we sent all wineries an online questionnaire by email, and we complemented it with telephone calls. We ended up with a total of 688 answers, which represents 19% of the AO population but 61% of its total production.[9]

Since the quality index we construct includes as components practices performed at the vineyard—such as fruit thinning or limiting grape density—the index cannot be calculated for wineries that buy grapes exclusively from third parties. Thus, we are forced to eliminate 42 wineries that do not own any vineyard (6% of the total sample), leaving a total of 646 wineries in the sample.[10]

Table I displays descriptive statistics for those 646 wineries. The majority of them are small. The

[6] Conferencia Española de Consejos Reguladores Vitivinícolas. Data accessed through the webpage https://vinosdo.wine/sala-de-prensa/el-sector-en-cifras/ in January 2023.
[7] This database was collected by the project "A firm level study of the global wine industry", explained in detail in Depetris Chauvin (2021).
[8] The survey grouped, respectively, two pairs of AO that are part of the same geographic area and are included in only one regulatory file as they are subject to the same regulatory agency. This left the dataset with 68 AO in total.
[9] The total response rate of 18.8% is well above the typical response rate of similar surveys, such as López-Rodríguez et al. (2018); Muñoz et al. (2020); Pérez-Luño et al. (2017).
[10] The potential econometric implications of the loss of observations is discussed in section III.B.

Table I: Descriptive Statistics

	N	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
A. *Continuous Variables*								
Hectares	646	183	966	0	9.2	20	61.8	20,000
Prod. Vol (in Mn of L)	646	1.2	6.9	0.002	0.035	0.1	0.35	150
Permanent Employees	646	8.5	20.6	1	2	3	6.8	260
Years in the market	646	33	35	1	14	21	37	300
N of Vinified Varieties	646	5	3.5	1	2	4	7	30
B. *Dummy Variables*								
Organic Production	646	0.27	0.44	0	0	0	1	1
Biodynamic Production	646	0.02	0.13	0	0	0	0	1
Conventional Production	646	0.40	0.49	0	0	0	1	1
Traditional Production	646	0.57	0.50	0	0	1	1	1
Red Wine	646	0.89	0.31	0	1	1	1	1
White Wine	646	0.76	0.43	0	1	1	1	1
Rosé Wine	646	0.46	0.50	0	0	0	1	1
Sparkling Wine	646	0.13	0.33	0	0	0	0	1
Sweet Wine	646	0.18	0.38	0	0	0	0	1
Other Beverages	646	0.05	0.22	0	0	0	0	1
C. *% of own grapes (VI)*	646	80.6	28.8	5	62.5	100	100	100

average number of permanent employees is 8.5 while the median is 3. In turn, the average number of hectares is 183 and the average liters produced per year is 1.2 million, with a median of 20 hectares and 100,000 liters, respectively. On average, wineries have been in the market for 33 years and vinify between four and five grape varieties. Most of the firms produce red or white wine (89% and 76%) and use the traditional or conventional type of production (57% and 40%, respectively).[11]

II.C Vertical integration and other forms of grape procurment

We construct a vertical integration (VI) variable as the percentage of grapes that comes from wineries' own vineyards. Since in the survey wineries were only asked to check interval categories, we use the mean of each interval as the data point. For example, we take 5% as the response for answers in the interval 0-10%. The average VI in the sample is 80.6% while the standard deviation

[11] The *Traditional* type of production uses agrochemicals and little or no mechanization, with methods that had been used for decades or even centuries. The *Conventional* type of production refers to production that, while still non-organic, uses more advanced methods at the vineyard, with a higher degree of mechanization. *Organic* production prohibits the use of agrochemicals in the vineyard. *Biodynamic* production is also an organic method but also involves holistic elements in the treatment of the land aimed at achieving a greater communion between grape cultivation and the environment.

is 28.8. Of the 646 wineries used in the sample, 351 (54%) are fully integrated; therefore, the VI median is 100%.

Wineries often combine the ownership of vineyards with the purchase of grapes from third parties. Buying grapes from third parties has several advantages. First, the high price of land, coupled with regulations that highly restrict vineyard area extensions (Castriota, 2020, ch.2,ch.3), implies that many wineries need to buy grapes to meet demand.[12] Second, vineyard monitoring costs (especially, in terms of oenologist visits) are proportionally higher the longer is the distance between the vineyard and the winery. Thus, beyond a distance threshold buying grapes from independent parties might save on those costs. Finally, consumer tastes can change suddenly, so the flexibility to externally buy grapes can help meet shifting tastes more rapidly.

Despite those advantages, buying grapes in the spot market can be too risky since the spot market for grapes—particularly for higher quality ones—is usually small and illiquid while certain weather contingencies can lead to sharp price increases. To avoid those risks, an alternative arrangement is to write contracts with grape suppliers. However, as grape-growing activities are subject to countless contingencies that forbids writing complete contracts, wineries usually prefer to build with grape growers relational contracts[13] where they annually agree upon criteria such as quality parameters (e.g., PH, sugar, phenolic grade, etc.), the number of kilograms, which hectares will be used to supply the winery, and the price formula that will determine the final payment.[14]

Under this modality, throughout the year the parties are mutually bound by the contract, so they are temporally locked into the relationship (see Tadelis 2002). Although there may be incentives to renege on the contract, hold-up problems are mitigated because behaving opportunistically would damage the reputation of the infringing party, thus harming prospects of dealing with that or other parties in the future.[15] Therefore, whenever changes and adaptations to the project are required as (climatic or biological) uncertainty unfolds, the conformity of both parties is needed to agree upon the actions to be undertaken. As Tadelis (2002) points out, if the temporal lock-in did not exist, the

[12] Failure to supply demand, even temporarily, entails the risk that consumers will change their preferences in favor of another product (Castriota, 2020, ch.2)

[13] Relational contracts are "informal agreements sustained by the value of future relationships" (Baker et al., 2002). The relationship itself becomes valuable as it provides certainty and predictability to the parties ensuring a future flow of income for the grape producer and input availability for the winemaker.

[14] See Codron et al. (2013) and Wilson et al. (2018) for a discussion of the use of contracts in the wine industry.

[15] See Macchiavello & Morjaria (2015) and Macchiavello & Miquel-Florensa (2017). See also MacLeod (2007).

winemaker could bid on the desired changes at each stage of the production process so that other parties would provide a suitable offer. The corollary is that adaptation requirements force parties to renegotiate.

As we will discuss later, when adaptation requirements are too strong, renegotiation costs, particularly in the form of inefficient outcomes, can make this type of arrangement undesirable. This will be especially the case for high quality grapes whose production is more complex and requires more response actions. In that case, stronger incentives for vertical integration will arise as a more efficient alternative.

III Quality and Vertical Integration

Numerous studies in different industries have shown that firms producing high quality products are more likely to be vertically integrated (Hansman et al., 2020; Hennessy, 1996; Martinez, 2002; Reardon et al., 2009), including the specific case of the wine industry (Fernández-Olmos et al., 2009). In this section, we show that the empirical relationship between vertical integration and quality also holds in our sample.

III.A Constructing an observable measure of quality

Measuring quality has been the focus of longstanding efforts in economics. A first approach to doing it in the wine industry inferred quality from the prices paid by consumers (Combris et al., 1997, 2000; Nerlove, 1995; Oczkowski, 1994), analogously to the common use of export unit values as a proxy for quality in international trade (Hallak, 2006; Kugler & Verhoogen, 2012; Schott, 2004). However, in addition to capturing markups, this type of measure also captures any non-physical attribute that makes consumers willing to pay extra for the product –for example, brand image, or bottle design (Hallak & Schott, 2011; Khandelwal, 2010). To avoid these problems, Crozet et al. (2012) narrowed the definition of wine quality to a more concrete measure that uses expert ratings as a proxy for their quality. Nevertheless, expert ratings have also been disputed as experts may have a different tasting experience than that of untrained drinkers.[16]

[16] See Castriota (2020, ch.2) for a detailed review of the criticisms to this type of measures.

As there is no single definition of quality in the wine industry (Charters & Pettigrew, 2007), and since we do not have information about the attributes of wines in our sample, we focus on practices that wineries adopt to achieve a higher sensorial quality for their wines. First, we construct a variable that captures a winery' aim to reach a certain level of (sensorial) quality rather than the actual quality achieved. Thus, we call this measure "pursued quality". Second, we focus on the "sensorial" dimension of wine quality. The advantage of this approach is that there is substantial agreement among winemakers that performing certain actions, ceteris paribus, enhances sensorial quality (see Reynolds 2010, Ch.11 and Van Leeuwen & Darriet 2016). Specifically, we construct a quality index composed of five equally-weighted dichotomous variables, each associated with a winemaking or agricultural practice that, according to our interviewees, unfailingly leads to higher organoleptic quality.[17] The five practices are:

1. *Fruit thinning*: discarding grapes before they ripen to favor the polyphenolic concentration of the wine.

2. *Sorting grapes before starting fermentation*: discarding damaged and diseased grapes to make wine from the best grapes of each vintage.

3. *Use of oak barrels (French or American) to age the wine*: the least invasive practice and the one that best highlights the singularity of each terroir.

4. *Use of natural cork*: prevents the passage of external oxygen to the wine which would damage its quality, allowing for better aging.

5. *Average grape density below the sample median*: decreasing the number of grapes allows the remaining ones to concentrate more polyphenols, enhancing wine sensorial characteristics.

Since the quality index is composed of five dichotomous variables it ranges from a minimum score of 0 to a maximum score of 5. Its mean value in the sample is 3.1, the median is 3, and the standard deviation is 1.3. Almost half of the wineries score a value of 3 or 4 in the index. The full sample distribution is as follows (number of wineries in parenthesis): 0 (12), 1 (63), 2 (117), 3 (193),

[17] Although consumers often perceive an organic wine as a quality wine (Gassler et al., 2019), we do not include "organic" as an attribute in our definition of quality as the presence of pesticides does not have a noticeable impact on the organoleptic parameters of the wine (for example, there is no predominance of organic wines in top places at blind tasting competitions-–Castriota 2020). Nevertheless, as discussed in the next subsection, including organic production as a control does not modify the main results.

4 (180), 5 (81). Regarding individual practices, 49% of the wineries perform fruit thinning, 85% sort the grapes, 61% use oak barrels, 72% use natural cork. The average grape density is 0.66 kg/m^2. In the survey, the questions about these practices refer only to the winery's lower-end wines.[18] Also, the subset of questions related to vineyard practices only ask about practices at vineyards owned by the winery—rather than about those at the vineyards' independent suppliers. We discuss these issues in the next section.

III.B Empirical Specification

Two key components of a winery's business strategy are the quality pursued for its wines and its degree of vertical integration. These two variables are decided upon together with many other business decisions aligned with the winery's strategy and thus can be thought of as being simultaneously determined. In this section, we evaluate the empirical relationship between these two variables. First, we note that they are positively correlated, with a Spearman correlation of 0.09. However, since this correlation is mediated by many other variables that might affect both the pursuit of quality and the extent of vertical integration, we control for those variables by estimating equation (1):

$$VI_i = \alpha + \beta \; Pursued \; Quality_i + Size_i + \gamma \mathbf{X}_i + \varepsilon_i. \tag{1}$$

The variable on the left-hand side of equation (1) is VI, the percentage of own grapes used in total wine production. The main variable on the right-hand side is our measure of pursued quality, proxied by the quality index. Equation (1) also includes a number of controls. First, it includes *Size*, measured by the log of the number of permanent employees. The size of a winery is expected to have a direct (negative) impact on vertical integration as larger wineries are restricted by AO regulations that limit vineyard ownership. Then, a set of additional controls—summarized as vector **X**—includes dummies for type of production (traditional, conventional, organic, or biodynamic), type of wine (red, white, sparkling, rosé, sweet or other), type of company (cooperative, limited liability company, joint-stock company, company in its own name, or other), and AO fixed effects. The term ε_i is the error term, assumed to be uncorrelated with the explanatory variables.

[18] In 73% of the cases in our sample, the winery's lower-end wine is an entry-level wine priced below 9 euros.

The coefficient of interest is β. This coefficient captures the strength of the association between vertical integration and the pursuit of quality. It is a partial correlation coefficient that measures how much the conditional expectation for *VI* increases when *Pursued Quality* is one point higher according to our index. We do not give β a causal interpretation. Doing this would require for identification exploiting exogenous variation in the pursuit of quality. However, this is not possible in our set up since observed variation in this variable is likely the result of many factors that also, directly and simultaneously, affect vertical integration. In section V, we will use exogenous variation in the extent of uncertainty to assess its affect on the correlation between VI and *Pursued Quality*.

There are further caveats to the interpretation of β. First, as mentioned, the quality index is constructed upon available information in the survey, which registers agricultural and winemaking practices corresponding to wineries' lower-end wines. In general, we expect wineries that seek higher quality for their lower-level wines to also seek higher quality for their entire wine portfolio. However, this could not necessarily be the case. For example, the estimation would be biased downwards if wineries make their highest quality wines using grapes from their own vineyards but buy grapes from third parties for their lower-level wines. Second, as also mentioned, our survey asks for practices only at the winery's own vineyards. In this case, to assess potential biases we will conduct robustness tests that can avoid this problem by alternatively constructing the index based only on practices at the vineyard. Third, we are unable to identify in the data some wineries that rent and fully manage third-party vineyards that have distinguishing characteristics for growing high-quality grapes. In this case, such a winery will not be observed to be vertically integrated although it is so as a matter of fact since it has complete control over all decisions at the vineyard. In this case, the coefficient of interest would be biased downwards.

III.C Empirical Results

The results of estimating equation (1) are displayed in Table II. In the first column, we only include *Pursued Quality* as the explanatory variable. An increase in one unit of this variable is associated with a 1.9 p.p. increase in VI, the percentage of own grapes used for winemaking. This relationship achieves statistical significance at the 10% level. Column (2) adds *Size* as a control. As expected, the estimated effect of size is negative as larger companies must source grapes from

Table II: Regression estimates

	Dependent variable:		
	Vertical Integration (VI)		
	(1)	(2)	(3)
Pursued Quality	1.9*	2.1***	3.0***
	(1.0)	(0.8)	(1.1)
Size		−6.8***	−6.0***
		(1.8)	(1.7)
Constant	74.7***	83.1***	117.9***
	(3.5)	(4.4)	(12.6)
Wine Type	No	No	Yes
Firm Type	No	No	Yes
Prod. Type	No	No	Yes
AO Dummys	No	No	Yes
Observations	646	646	646
R^2	0.01	0.1	0.3
Note: clustered standard errors in parentheses, at the AO level	*p<0.1; **p<0.05; ***p<0.01		

third parties to continue growing due to plantation size restrictions. The coefficient on *Pursued Quality* is quantitatively unaltered but becomes significant at the 1% level. Column (3) adds fixed effects by type of wine, firm, and production (see section III.B) and by appellation of origin (AO). Once we control for these fixed effects, the coefficient on *Pursued Quality* increases: one additional unit (standard deviation) in this variable is associated with a 3.0 p.p. (3.9 p.p.) increase in VI. The coefficient remains significant at the 1% level. All regressions are clustered at the AO level.

The results confirm in our sample those found in the literature: there is a positive relationship between quality and vertical integration. This relationship is consistent with the notion that firms vertically integrate to ensure high quality inputs for their products. In the next section, we discuss the potential mechanisms behind this relationship while in the following one we provide evidence for the empirical relevance of adaptability as one of these mechanisms.

We perform several robustness tests. The results are displayed in Table III. As a benchmark, column (1) replicates the baseline specification, which is the full specification in column 3 of Table II. In column (2) we use clustered robust standard errors at the province level rather than at the AO level. Geographically, only 30% of the 68 Spanish AO are present in more than one province. Clustering at the province level does not have a substantial effect on the estimated standard errors.

Table III: Robustness Exercises

	Dependent variable:					
	Vertical Integration (VI)					
	(1)	(2)	(3)	(4)	(5)	(6)
Pursued Quality	3.0***	3.0***	3.3**			2.8***
	(1.1)	(1.0)	(1.3)			(1.1)
Pursued Quality (Only Winemaking practices)				1.9		
				(2.5)		
Self-reported Quality					3.3*	
					(1.8)	
Age						−2.1
						(1.5)
Variety Diversification						0.4
						(0.4)
Size	−6.0***	−6.0***	−6.7***	−5.6**	−5.9***	−6.0***
	(1.7)	(1.1)	(1.7)	(2.2)	(2.1)	(1.7)
Constant	117.9***	117.9***	123.0***	104.3***	90.4***	124.6***
	(12.6)	(11.7)	(13.8)	(17.3)	(20.0)	(11.1)
Wine Type	Yes	Yes	Yes	Yes	Yes	Yes
Firm Type	Yes	Yes	Yes	Yes	Yes	Yes
Prod. Type	Yes	Yes	Yes	Yes	Yes	Yes
AO Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	646	646	581	688	688	646
R^2	0.3	0.3	0.3	0.3	0.3	0.3

Note: clustered standard errors in parentheses, at the the province level in column (2), at the AO level otherwise *p<0.1; **p<0.05; ***p<0.01

The second robustness exercise eliminates from the sample those wineries that are cooperatives (65 in total) since, as cooperatives use grapes from several partners, the answers to the survey questions that make up our quality index may not be representative of the practices of all supplying partners. As shown in column (3), the results are robust to excluding cooperatives from the sample (they are even slightly stronger).

Another robustness exercise consists of defining the quality index exclusively using practices at the winery (grape sorting, use of oak wine aging, use of natural cork)—rather than at the vineyard—to be able to include those 42 wineries that exclusively buy grapes from third parties. The results are shown in column (4). In this specification, the coefficient of interest is still positive, but it is not statistically significant.[19] A potential explanation of this result is that we lose relevant variation in the explanatory variable by not considering practices at the vineyard.

[19] We verify (not shown here) that this result is not driven by the fact that new observations are added to the regression.

In column (5), as an alternative measure of quality we use a self-reported measure of quality based on a question in the survey that asks the respondent to rate the winery in terms of its quality relative to the competition. This measure ranges from 1 to 5 but displays limited variability: both the 25^{th} percentile and the median of the variable is 4, while 242 wineries (35% of the total) report a value of 5. The advantage of this alternate measure of quality is that it can be used for all 688 wineries in the sample. Its correlation with the quality index (in the subsample that excludes the 42 wineries with no vineyards) is 0.15. As shown in column (5), the coefficient for the self-reported quality variable is slightly greater than in the baseline specification but it is statistically significant only at the 10% level. Here, a potential explanation for the weaker result is that this measure captures other dimensions of quality besides physical quality, such as design, marketing, and customer service, which a winemaker might consider "quality" but whose assurance does not require vertical control of the vineyard.

Finally, column (6) controls for *Age* (log number of years the winery has been in the market) and *Varietal Diversification* (number of varieties vinified). We include *Age* because older wineries could be less vertically integrated as they had more time to develop trustworthy relationships with independent suppliers. Also, some wineries could decide to externally procure grapes of certain varieties their *terroir* is not suitable to deliver at an appropriate quality. Neither of these controls is statistically significant nor their inclusion alters the main result.

IV Discussion of potential mechanisms

Quality (un)observability has monopolized so far the inquiry about potential mechanisms behind the relationship between quality and vertical integration. For example, Hennessy (1996) posits that uncertainty about food quality is the main cause of the trend towards vertical integration in agriculture. Martinez (2002), analyzing the poultry and swine industries, explains that vertical integration serves to reduce quality measurement costs. More recently, Hansman et al. (2020) use a strong identification strategy to establish that the impossibility of adequately verifying fish protein content–the relevant measure of quality in their setup–at the time of the supplier-buyer transaction is the underlying driver of vertical integration in Peru's fishmeal industry.

In this section, we first argue that quality unobservability should not be a critical determinant of vertical integration in the wine industry and thus cannot be a relevant explanation behind the results of section III. Then, we discuss the adaptability (Bajari & Tadelis, 2001; Januszewski Forbes & Lederman, 2009; Tadelis, 2002) as a plausible alternative explanation.

IV.A Unobservability of input quality

Three reasons support the notion that unobservability of grape quality cannot be a relevant mechanism driving vertical integration in the wine industry. First, the main attributes that determine grape quality are acidity, sugar (to determine potential alcohol content), pH, and glycolic acid. The technical analyses needed to measure these attributes are not very costly and most wineries usually have the necessarily equipment to perform them on their own. In fact, compliance with required parameters for some of these variables, as well as with others related to skin color and condition, seed color, and degree of ripeness, can be checked by simply viewing and tasting the grapes.

Second, the main biological threats to plant health are attacks by various types of fungi and pests such as ovid, downy mildew, phylloxera, and botrytis, among others. The effect of these attacks is visible to the naked eye and causes bad taste in the fruit. Thus, whether the grape is healthy or has some disease can again be determined by simply observing and tasting it. Third, quality control is not exclusively conducted at the time of the transaction; both formal and informal contracts contemplate winery visits to independent suppliers' vineyards. Wineries can even provide advice to independent growers on technical issues such as fungicide or pesticide application. In sum, the main parameters that influence the organoleptic quality of the grapes are easily observable or easily measurable.[20]

IV.B The need for adaptation in the pursuit of quality

Since vines are living organisms subject to the ups and downs of weather during the year, producing quality grapes requires from the farmer a great capacity of fast reaction.[21] The impact of climatic phenomena (hail, frost, rain, sun exposure, thermal amplitude, average temperature, winds, etc.) on the vine will depend, among many other factors, on the time of occurrence and on parameters such as altitude, soil type, vineyard age, grape variety, and the plantation orientation. Given the innumerable

[20] An agronomist from an important winery stated that, although he used grapes from his own vineyard to produce his best wine, if he went to the market he would be able to tell exactly whether the grapes traded were suitable for making that same wine. See, for example, https://www.winebow.com/our-brands/catena-zapata/catena-zapata-malbec-argentino/2018 for details of relevant factors for sensory quality.

[21] See Sommers (2008); Tonietto & Carbonneau (2004); Vaudour (2002).

combinations of these parameters, as well as the variety of climatic contingencies, there is no single recipe to achieve quality grapes. Rather, quality is achieved with adequate agricultural responses to the vicissitudes of the environment. In case of excessive sun exposure, for example, certain grape variety may require irrigation support while another one may not. Or, depending on the orientation of the vineyard, strong blizzards may damage the plant requiring repair treatments on the wood.

Although adaptation of viticultural practices to climatic contingencies is always required, adaptation needs increase with the pursued quality of the wine.[22] Wineries that produce high quality wines seek to differentiate them from competing ones by a specific combination of organoleptic attributes. Once those attributes are achieved, they try to preserve them across vintages as consumers' perception of intrinsic quality fosters brand loyalty and buying intention (Fandos & Flavian, 2006). This requires continuously adjusting viticultural practices to always obtain a wine whose essence is unaltered. By contrast, consumer loyalty to lower-quality wines is arguably less dependent on their organoleptic attributes as price is a more predominant consideration in these wines' purchasing decisions.

Several decisions must be made to maintain the pursued level of quality in response to weather contingencies.[23] For example, since rainfall lowers the concentration of polyphenols[24] in the grapes, when rainfall is abundant maintaining pursued quality levels would require pruning, which restores polyphenol concentration. On the contrary, when rainfall is scarce irrigation will be of vital importance to achieve the desired grape quality.

A second decision that involves reacting to uncertain events relates to the time of harvest (Rodríguez & San José, 1995). On the one hand, delaying the harvest time increases the sunshine and high-temperature exposure of the grape, which favors ripening by enhancing sugar concentration and impacts on other chemical components that may be of oenological interest to achieve wines with desired attributes (e.g., more acidic, or stronger wines). On the other hand, postponing the harvest implies a higher probability of rainfall—at a time of the year where rainfall is more likely—with its negative implications on the concentration of polyphenols and thus on grape quality. Faced to this tradeoff, the decision about the optimal time to harvest largely implies observing and tasting the

[22] On a related issue, some papers point out the importance of adaptation to long-term climatic change. See, for example, Ashenfelter & Storchmann (2020), Mozell & Thach (2014), Mosedale et al. (2016), Anderson et al. (2008), Van Leeuwen & Destrac-Irvine (2017).

[23] See Reynolds (2010) for a compendium of prescriptions to farmers about recommended responses to a variety of climatic events.

[24] Polyphenols are chemical elements that determine wines' organoleptic power (see Zago 2009).

grapes and is based on subjective assessments that are difficult to specify in a contract.

Finally, a crucial decision to safeguard the quality of grapes and vines involves adequately adapting to the occurrence of hail, the most feared climatic event in the wine world (Cagnetti et al., 2013; Wilson, 1998). While critical, the optimal response to hail is very difficult to specify ex-ante due to uncertainty about how and when hail may occur. The optimal response will depend, for instance, on the wind speed, the size of the stones, the degree of damage to the vine, and the vine's age. The time of occurrence is also important. If the storm were to occur early in the season, the vine would have time to generate new fruit from secondary shoots, albeit with some loss of quality due to delayed plant development and lack of nutrients from damaged leaves (Fahey & Englefield, 2019). After the budbreak phase, hail can cause not only crop losses but also severe quality loss as grape wounds generate bitterness and increase the risk of fungal invasion. The loss of leaves can also compromise the level of sugars in the following vintage by affecting the plant's capacity to produce starch.

Response actions that help mitigate these harmful effects include pruning, eliminating all affected bunches (even resigning the season's production); harvesting earlier than usual; removing leaves to ventilate the plants; and applying treatments on the wood to enhance healing and prevent the appearance of fungi (powdery mildew and Botrytis)—especially at the end of the season when humidity is higher. All of these actions, however, require a careful diagnosis of the damage to the plant as well as care and timing in their implementation. In sum, flexible decision-making is critical to achieve high quality grapes.

Wineries' organizational structure—whether or not they are vertically integrated—affects their ability to make flexible decisions in response to unpredictable events, particularly hail. The occurrence of such events triggers the need to react rapidly to minimize quality loss. However, high uncertainty in production outcomes renders the specification of a complete contract about contingent actions an impossible objective (see, for example, Bajari & Tadelis 2001). In this context, wineries involved in a bilateral relationship with an independent producer find themselves in a temporal lock-in situation (Tadelis, 2002) where adapting to contingencies requires renegotiating the previous agreement.[25] The renegotiation can be highly contentious because reacting appropriately to contingencies often

[25] It is worth stressing that underlying a temporal lock-in situation is usually some form of specific investment (see Klein 1980; Klein et al. 1978; Lafontaine & Slade 2007; Williamson 1971). However, the adaptation mechanism could also operate in situations where decisions have to be made fast soon after uncertainty unfolds (Gibbons, 2005).

involves incurring new costs whose bearer has not been specified in the contract. As exiting the relationship is costly, wineries may decide to adopt suboptimal practices not to disrupt the relationship with the other party. As a consequence, obtaining pursued quality levels may be problematic.

Indeed, many of our interviewees emphasized the difficulties involved in reaching an agreement with producers over certain decisions oriented to preserve quality in the face of adverse climatic events. Using irrigation and applying chemicals to treat mineral deficits, reducing plant yields to mitigate (event-induced) quality loss, or delaying harvest time–which increases the risk of hail or fungal attacks–are all examples of required response actions that increase costs and risks.[26] Thus, in the case of high-quality grapes the anticipation of renegotiation costs over who bears the costs and risks of adaptation actions may overturn the advantages of buying grapes from independent parties discussed in section II. In that case, vertical integration arises as an organizational structure with the advantage of providing more flexibility for rapid decision-making in response to contingencies.

V Adaptability and vertical integration

V.A Measuring adaptation needs

Finding a summary measure of adaptation needs at the vineyard is a challenging task. Adaptation needs stem from many different climatic events and depend on factors such as the vineyard's altitude, age, and planting orientation. However, we can focus on the undoubtedly most feared climatic event in the wine industry: hail (Cagnetti et al., 2013; Wilson, 1998). Hail is an infrequent event (it occurs on average less than once a year) that causes severe damage to vines and triggers the need to react rapidly with a variety of response actions. Thus, as a measure of adaptation needs we use the average number of hail days per year between April and August, and consider this measure the sample counterpart of the probability that a hail episode occurs during that period. Although the damage severity of a hail episode depends on many factors such as its intensity and duration, this variable should be a reasonable *proxy* for the need to introduce adaptations to minimize damage to

[26] Vine care for high-quality wines is particularly labor intensive as it must be carried out with extreme caution. According to one of our interviewees, 70 *jornales* (8 work hours) per hectare are needed for pruning in the case of grapes destined to their higher quality wines whereas only 8 *jornales* per hectare are needed for those destined to their intermediate quality ones.

vine quality.[27] Thus, the larger is the probability of a hail event a winery is exposed to, the larger will be the adaptation needs it will expect to face. When vineyard and winery are independent parties, undertaking the required actions will imply high renegotiation costs and thus potentially induce vertical integration to avoid paying them.

To construct this variable, we use a database assembled by the Spanish State Meteorological Agency (AEMET) from 81 weather stations. For each station, the database reports monthly series from 2000 to 2020 of recorded days of hail during April to August. During these months, the vine goes through three key stages, namely foliation, flowering and budbreak, where first leaves, and then grapes, are directly exposed to the inclemency of hail. In particular, the destruction of leaves deteriorates the ability of the vine to produce sugar content while injuries to grapes cause bad tasting and bitterness. Hail before that period is less dramatic as vines have time to recover on their own, generating secondary shoots–albeit potentially of lower quality.

Using geographical information for wineries and weather stations we can calculate the distance between each winery and each station. Ideally, one would like to register hail data right at the wineries' location. Of course, this coincidence is rarely met: 75% of the wineries have the nearest station at least 20km away and the average distance to the nearest station is 33km. Additionally, most wineries have several stations nearby, each providing independent information about hail probabilities at the winery's location that would be useful to exploit. Thus, considering (at most) the closest four stations within a 60km radius—and giving more weight to more proximate ones—for each winery i we construct the following measure of hail probability:

$$Hail_i = \sum_{k=1}^{K} \frac{h_k * \left(\frac{1}{d_{ik}}\right)}{\sum_{j=1}^{K} \left(\frac{1}{d_{ij}}\right)}$$

where h_k is the number of average hail days in station k and d_{ik} is the distance between winery i and weather station k, with $k = 1, 2, 3 \ldots$ being the k^{th} closest station to winery i, and K the number of total stations that are less than 60km away. According to geographers consulted, it is reasonable to infer the probability of hail from hail data at distances within a radius of 60 km, especially considering a historical average of 20 years.[28] Analogously, we took a maximum of four stations

[27] Januszewski Forbes & Lederman (2009) use hail to measure adaptation needs in the airline industry.
[28] There are 69 wineries that do not have a station within a 60km radius. In those cases, we assign the data from the

because information from additional stations could be redundant. Nevertheless, as we discuss later, the results are robust to alternative choices for this measure.

The variable $Hail$ ranges between 0 and 4.3 days per year, with a mean of 0.85 days, median of 0.6, and standard deviation of 0.7. We can think of this variable as being reported by an artificial station located at a certain implicit distance from the winery. This implicit distance can be computed using the formula for $Hail$ but replacing d_{ik} for h_k. This is equivalent to computing $Impdist_i = K * \frac{1}{\left(\sum_{k=1}^{K} * \frac{1}{d_{ik}}\right)}$. The implicit distance is short for the majority of wineries. The mean implicit distance is 37.5 km while the third quartile is 47km. Only for 69 wineries (10% of the total) it is greater than 60km and for 13 wineries it is greater than 80 km.

A potential problem with our measure is that we consider the winery's location (which we know) rather than the vineyards' one (which we do not know) as the relevant location to compute days of hail. However, vineyards are usually not far from the winery due to the transportation costs—grapes and human resources—that would be involved if they were located far apart. Also, at harvest time, since grapes off the vine quickly start to ferment, long distances between vineyard and winery could impair the quality of the final wine.

V.B Empirical specification and results

While section III established that wineries that pursue higher quality also tend to be more vertically integrated, this section examines whether adaptability is a relevant force behind this relationship. More specifically, using the number of hail days (*Hail*) as a proxy for adaptation needs, we examine whether the relationship between the pursuit of quality and vertical integration is stronger for wineries more subject to those needs, i.e., in locations more exposed to hail. Thus, we expand the empirical specification in equation (1) by adding and interaction term between the variables $PursuedQuality$ and $Hail$. The resulting specification is equation (2) below, where the coefficient of interest is β_3. A positive estimated coefficient would indicate that in areas with more average days of hail, the relationship between quality and vertical integration is stronger. It is important to notice that exploiting differences in exposure to hail provides a source of exogenous variation across wineries in their need for adaptation. Since AO fixed effects are included in the regression, only hail-exposure

closest station regardless of its distance to the winery.

Table IV: Estimation Results. Adaptation mechanism (OLS)

	Dependent variable:		
	Vertical Integration (VI)		
	(1)	(2)	(3)
Pursued Quality	0.4	1.1	0.8
	(1.4)	(1.1)	(1.2)
Hail	−5.2	−2.8	-8.9^{*}
	(4.9)	(4.8)	(4.6)
Quality * Hail	1.7	1.1	2.7^{**}
	(1.3)	(1.2)	(1.2)
Size		-6.8^{***}	-5.8^{***}
		(1.8)	(1.7)
Constant	79.1^{***}	85.5^{***}	123.3^{***}
	(4.9)	(5.4)	(12.4)
Wine Type	No	No	Yes
Firm Type	No	No	Yes
Prod. Type	No	No	Yes
AO Dummys	No	No	Yes
Observations	646	646	646
R^2	0.01	0.1	0.3

Note: clustered standard errors in parentheses, at the AO level $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

variation across wineries *within* AO is exploited to identify β_3. Other potentially confounding sources of variation across wineries located in different AO are already controlled for by these fixed effects.

$$VI_i = \alpha + \beta_1 Pursued\ Quality_i + \beta_2 Hail_i + \beta_3 (Pursued\ Quality_i \times Hail_i) + \gamma \mathbf{X}_i + \varepsilon_i. \quad (2)$$

The results of estimating equation (2) are reported in table IV. In column (1), only the interacted terms are included in the regression. The interaction term is positive but it is not statistically significant. Column (2) introduces winery size as a control while column (3) introduces the set of dummies for wine, firm, and production type, as well as the AO dummies. Introducing winery size does not qualitatively change the results. However, once the full set of dummy controls are included, the coefficient on the interaction term becomes larger in magnitude and significant at the 5% level. We take this latter specification as the baseline estimation.

The results support the hypothesis that adaptability is an important driver of the relationship between quality and vertical integration. The stronger is the need for adaptation due to climatic uncertainty, the higher are the renegotiation costs that high quality wine producers will want to avoid by vertically integrating with their supplying vineyards. The empirical results imply that for a winery located at the 25^{th} percentile of the distribution of $Hail$ (0.5 hail events per year), an increase in one standard deviation in *Pursued Quality* is associated with a 2.9 percentage point increase in VI. However, for a winery located at the 75^{th} percentile (1.15 hail events per year), the same increase in $PursuedQuality$ is associated with an increase of 5.2 percentage points in VI. This difference across the interquartile range of $Hail$ represents 8% of the standard deviation in VI across our sample of wineries.[29]

We conduct a number of robustness checks. First, we redo the robustness checks performed in section III, now applied to this expanded specification. The results are displayed in Table V. As a benchmark, column (1) replicates the results of the baseline specification (column 3 of Table IV). In column (2), we cluster standard errors at the province level rather than at the AO level, with no relevant affect on the results. In column (3), we remove cooperatives from the sample. The magnitude of the coefficient on the interaction term slightly diminishes but remains significant at the 10% level. In column (4), we use the alternative quality index that does not include vineyard practices. In contrast to the results in section III, the value of the coefficient on the interacted variable increases while preserving its statistical significance at the 5% level. In column (5), we redo the previous regression but drop the new observations that are added when we only focus on vineyard practices. In this case, the main coefficient's significance drops to the 10% level but its estimated magnitude is only slightly altered.

In column (6), we substitute the self-reported quality measure for our quality index. As in section III, the main result is not robust to this alternate measure. As discussed, we attribute this result to the fact that self-reported quality includes other dimensions of quality not necessarily associated with the need for adaptation. Finally, in column (7), we add controls for *Age* and *Varietal Diversification*. When we add these controls, the coefficient on the interaction term remains unaltered

[29] When we evaluate the results at the average number of hail days, the estimated partial effect of quality on vertical integration $(\beta_1 + \beta_3) * \overline{Hail}$ yields 3.2, a coefficient that is only slightly higher than in the baseline specification (without the interaction term) of section III. The joint test that both β_1 and β_3 are jointly zero is rejected at the 1% level.

Table V: Robustness exercises for the adaptation mechanism

	Dependent variable:						
	Vertical Integration (VI)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pursued Quality	0.8	0.8	1.3				0.7
	(1.2)	(1.3)	(1.5)				(1.2)
Pursued Quality (Only winemaking practices)				−1.1	−0.7		
				(1.6)	(2.7)		
Self-Reported Quality						5.5*	
						(3.3)	
Avg. Hail	−8.9*	−8.9*	−6.9	−1.1	0.7	12.7	−8.6*
	(4.6)	(5.2)	(5.5)	(2.2)	(2.5)	(10.7)	(4.7)
Pursued Quality*Hail	2.7**	2.7**	2.4*				2.7**
	(1.2)	(1.4)	(1.3)				(1.2)
Pursued Quality (only Winery)*Hail				3.2**	3.0*		
				(1.6)	(1.8)		
Self-Reported Quality * Hail						−2.7	
						(2.3)	
Age							−2.1
							(1.5)
Varietal Diversification							0.4
							(0.4)
Constant	123.3***	123.3***	127.6***	124.1***	108.8***	79.0***	129.7***
	(12.4)	(11.8)	(13.7)	(11.4)	(13.7)	(27.2)	(10.9)
Wine Type	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AO Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Type	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prod. Type	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	646	646	581	646	688	688	646
R^2	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Note: *p<0.1; **p<0.05; ***p<0.01

compared to the baseline specification while preserving statistical significance at the 5% level. All the specifications—except for the robustness test in column (2)—use cluster robust standard errors at the AO level.

We conduct an additional set of robustness tests, displayed in Table VI. Once again, for reference column (1) replicates the results of the baseline specification. In columns (2) and (3), we modify the threshold distance for stations to be included in the calculation of $Hail$. Specifically, we modify the 60km threshold for alternative thresholds of 40km and 80km, respectively. In both cases, the magnitude of the estimated coefficient decreases but is not substantially altered while it maintains statistical significance at the 5% level. In columns (4) and (5), rather than considering a maximum of four weather stations in the calculation of $Hail$, we alternatively consider three and five stations, respectively. As can be seen in the table, this change has unnoticeable incidence on the results.

In column (6), under the idea that the quality of information captured by $Hail$ may falter when the nearest weather station is far away, we drop the 69 observations that have the closest station beyond

60km. In this case, both the magnitude and the significance of the interaction term increases, the latter becoming significant at the 1%. Following the same idea, but applying it more generally, in column (7), we estimate using Weighted Least Squares with weights given by $\frac{1}{d_i^2}$ (that is, inversely proportional to the winery's distance to the weather station). By using these weights, we confer more weight to observations whose information come from more proximate stations. Under this specification, the coefficient of interest more than doubles while keeping significance at the 5% level. Evaluated for a winery located at the 25^{th} percentile of *Hail*, a standard deviation increase in *Pursued Quality* is associated with a 2.0 percentage point increase in VI while it is associated with a 7.3 percentage point increase in this variable when evaluated for a winery located at the 75^{th} percentile. This interquartile difference represents a considerable fraction (18.5%) of the standard deviation in VI across the wineries in the sample.

Table VI

	Dependent variable:						
	Vertical Integration (VI)						
	60km	40km	80km	3 stations	5 stations	w/o stations > 60km	60km (WLS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pursued Quality	0.8	1.2	0.6	0.8	0.8	−0.7	−1.4
	(1.2)	(1.3)	(1.5)	(1.2)	(1.2)	(1.2)	(1.6)
Avg. Hail	−8.9*	−7.7	−13.2***	−8.9*	−8.9*	−13.3***	−22.3***
	(4.6)	(4.8)	(4.4)	(4.6)	(4.6)	(5.1)	(8.4)
Pursued Quality*Hail	2.7**	2.3**	2.5**	2.7**	2.7**	4.8***	6.0**
	(1.2)	(1.2)	(1.0)	(1.2)	(1.2)	(1.6)	(3.0)
Constant	123.3***	122.5***	123.6***	123.2***	123.3***	128.4***	142.4***
	(12.4)	(12.5)	(12.6)	(12.4)	(12.3)	(11.7)	(11.8)
Wine Type	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AO Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Type	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prod. Type	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	646	646	646	646	646	577	646
R^2	0.3	0.3	0.3	0.3	0.3	0.3	0.6

Note: *p<0.1; **p<0.05; ***p<0.01

Considered as a whole, the results support the empirical relevance of adaptability as a driver of the observed relationship between quality and vertical integration. In the wine industry, where input characteristics are observable, the need for adaptation to climatic contingencies arises as an alternate force inducing high quality vineyards to vertically integrate. In locations more exposed to adaptation needs—those exposed to a higher frequency of hail—the pursuit of higher quality is more strongly associated with vertical integration. Since the need to adapt to climatic contingencies increases with the pursued wine quality, high-quality wine producers, foreseeing higher renegotiation costs and the risk of inefficient outcomes, have more incentives to vertically integrate to preserve their ability to make quick and undisputed contingent decisions.

Given the wide variety of economic activities subject to similar uncertainties, particularly in agriculture due to climatic events but in other industries as well such as those subject to rapid demand shifts or strongly dependent on new technologies, we think the relevance of our results are broad. Thus, in addition to input quality unobservability, adaptability should also be considered a relevant mechanism driving the observed relationship between quality and vertical integration.

VI Conclusion

Numerous studies have found that firms vertically integrate in order to achieve higher quality. However, the single mechanism uncovered so far as a driver of this relationship is the impossibility of observing input quality. By contrast, the theoretical literature on vertical integration suggests that other mechanisms may be at work, which have not yet been explored in the quality context. Salient among them is the need for adaptation. To the best of our knowledge, this is the first paper linking quality, vertical integration, and adaptability. We use a survey of 688 Spanish wineries and collect hail data from 81 meteorological stations to study this relationship.

We construct an index based on five practices (at the vineyard and in the winery) that unfailingly lead to higher sensorial quality. We call this index "pursued quality". First, we show that the positive relationship between vertical integration and quality previously found in the literature also holds in our sample. Then, we explore if the need for adaptation in response to the realization of uncertain events is a relevant mechanism behind this relationship. We test this mechanism empirically—exploiting exogenous variation in winery' exposure to hail as our uncertainty variable—, and find that the positive relationship between quality and vertical integration is robustly higher for firms exposed to a larger probability of hail.

Taken together, our results indicate that firms pursuing higher levels of quality are more likely to vertically integrate to preserve adaptability and thus avoid the high renegotiation costs and risks of inefficient outcomes that would be spurred by the occurrence of unforeseen events. We think that these results also apply to other industries subject to similar uncertainty where vertical integration should also be expected to enable high quality producers to adapt rapidly to preserve pursued quality levels.

A Appendix I. Correlation Matrix

Table VII: Correlation Matrix

	Pursued Quality	Vertical Integration	Permanent Employees	Years in the Market	Volume of Prod (in L)	Hectares sold	N of varieties Prod	Organic Prod	Biodynamic Prod	Conventional Prod
Vertical Integration	0.09*									
Permanent Employees	0.03	-0.16***								
Years in the market	-0.14***	-0.10*	0.28***							
Volume of Production (in L)	-0.03	-0.01	0.47***	0.17***						
Hectares	-0.03	0.06	0.42***	0.14***	0.95***					
N of varieties sold	-0.01	-0.05	0.27***	0.15***	0.25***	0.24***				
Organic Prod.	0.04	0.02	0.13**	0.06	0.13***	0.13**	0.30***			
Biodynamic Prod.	0.04	0.03	0.01	0.00	-0.02	-0.02	0.03	0.11**		
Conventional Prod.	0.12**	-0.10**	0.07	0.00	0.07	0.05	0.06	-0.15***	-0.08*	
Traditional Prod	-0.16***	-0.10*	0.04	0.07	0.08*	0.07	-0.11**	-0.39***	-0.08*	-0.37***

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