Price Dispersion in Wines[++]

J.M. Cardebat*, O. Gergaud**, P. Régibeau†, K. Rockett‡

Draft, April, 2021

Preliminary. Comments welcome

Abstract

We investigate empirically and theoretically price dispersion in wines sold in restaurants. We begin by measuring price dispersion in a rich dataset of Bordeaux wines sold in restaurants in a series of cities over a three-year period. Following recognised methodology for cleaning product differentiation from the data, we measure the change in price dispersion as competition varies in the market. We find a robust result that price dispersion increases with competition. We then review the institutional features of restaurant sales of wines before proposing a spatial model capturing these features to explain why this market appears to exhibit increasing dispersion with competition. In this model, restaurants face two types of customers, "connoisseurs" who have definite preferences for particular wines and "tourists" who do not. We find that an indirect effect flows through the price of food, which is announced and known by customers before patronising the restaurants, to the pricing of wine, which is only revealed once the customer enters the restaurant and receives the wine list. Competition puts direct pressure on food margins, which decreases the total food plus wine "takings" from a wine connoisseur who chooses to patronise the restaurant. Hence, retaining wine connoisseurs via an attractive price on a good bottle becomes less attractive and so pressure on wine prices is reduced. This opens the door for increased dispersion. The results add to both the literature on "add ons" and to recent work on price dispersion in markets where bundles of goods are purchased.

[*] Cardebat: LAREFI, U. Bordeaux; [**]Gergaud: KEDGE, Bordeaux Business School; [†]Régibeau: European Commission, University of Essex; [‡]Rockett: University of Essex, CEPR. Comments in correspondence to kerock@essex.ac.uk gratefully received.

1. Introduction

Price dispersion, understood as the variance of prices in a market once all underlying sources of heterogeneity have been controlled for, has been studied in empirical and theoretical economic papers. One might expect competition among firms to eliminate price dispersion so that, for example, dispersion should fall as competitive pressures rise. Empirically, however, prices in an apparently homogenous good market may not conform to the "law of one price". Price dispersion has been found to characterise online goods (Baye, Morgan and Scholten, 2004), automobiles (Goldberg et al, 2004; Verboven, 1999)and supermarket products (Dubois and Perrone, 2015). More directly related to our work, Kaplan et al (2019) study retail markets, showing that where consumers purchase multiple goods potentially in a bundle, and show that where some are "captive", highly competitive markets are compatible with price dispersion[1]. Borenstein and Rose (1994) derive early results for airline prices showing that dispersion can increase as competition increases[2]. Lewis (2008) and Pennerstorfer et al (2020) also find increasing dispersion with competition in gasoline markets, although Syverson (2007), studying cement, finds the opposite pattern.

Many of these studies focus on relatively low value products and frequent purchases. In this paper, we study a relatively high value product which is purchased less frequently: wine that is part of a restaurant meal. In particular, we study how price dispersion in wine changes as competition varies. We then develop a bespoke theory of price dispersion adapted to this market, where the behaviour of price dispersion in the wine component of the bundle is influenced by the food component's pricing behaviour. While bespoke, we believe that our model captures features that could be of interest outside our own example market where products are consumed in bundles.

Our first step is to characterise price dispersion in the data. We strip away as many complexities as possible to allow us to identify price dispersion in wines separately from the significant effects of heterogeneity. Using a dataset of Bordeaux wines sold in restaurants, we use a two-step procedure that is common in the literature to remove heterogeneity (see Pennerstorfer et al, 2020, as a recent example)[3] and then test the relation of price dispersion to competition. Our unique and rich data allows us to sift through many of the complications of this market to generate a "cleaned" residual price for a "homogenised" good. Fixed effects

[1] Other empirical papers supporting a general observation of price dispersion in a variety of markets include but are not limited to Stigler (1961), Pratt, Wise and Zeckhauser (1979), Brynjolfsson and Smith (2000), Goldberg and Verboven (2001), Hong and Shum (2006), Galenianos, Pacula, and Persico (2012), Woodward and Hall (2012). See Kaplan et al (2019) for a recent summary and Varian (1980) for a survey of some of the first formal models in this area.

[2] Gerardi and Shapiro (2009) sound a note of caution for this entire empirical literature. They show that the Borenstein and Rose (1994) results reverse with application of a sophisticated econometric analysis using entry to identify price dispersion as a response to increased competition with careful control of differentiating factors such as ticket categories. The empirical finding of price dispersion remains extremely widespread, however, using a large number of techniques. It also obtains theoretical support both here and in other papers.

[3] See also Lewis (2008) and Dubois and Perrone (2015) as further examples of this technique.

allow us to capture other important features such as market-level cost shocks and population movements[4]. We then test the dispersion of this residual price against factors of interest such as competition.

Our results from the first stage suggest substantial dispersion in the cleaned price. Our focus, however, is on the second stage where we relate dispersion to competition. We find that dispersion increases with restaurant density at all geographic levels from neighbourhood to city. We control for a variety of characteristics of these restaurants as part of this second stage, including location in order to pick up any confounding effects of income variation, cuisine, and various measures of "quality" to track how dispersion varies with these groupings. In our log-log framework, the coefficient on competition's effect is around .2, although this varies across cities and geographic levels, suggesting a substantial (percentage) effect of increasing competition on price.

We then turn to an explanation of these empirical results. We represent the restaurant market by a spatially distinct set of outlets that sell meals composed of (undifferentiated) food and a choice of one of two wines from a wine menu that is only available once the customer has committed to the restaurant[5]. Hence, any meal is conceived as a pure bundle. Customers may be of several types: some purchase only once at an establishment ("tourists"), after which they disappear from the market[6]; others are repeat purchasers who return to the establishment in the future to enjoy an experience that becomes completely known to them but is nonetheless enjoyable ("connoisseurs"). There may also be heterogeneity within this repeat customer group in exactly what they value in a wine so that members of this group may differ in their preferred wine. Such heterogeneity in tastes rather than a single "best to worse" quality ranking for wines has been well documented in the literature (Oczkowski, 2017, for example). Tourists, on the other hand, simply purchase the cheaper of the two wines, whichever it is (they do not perceive the differentiation).

We characterise pricing and consumption behaviour in this framework, focussing on conditions under which price dispersion arises. We find that the price of the food portion of the meal falls as competition (measured by the density of establishments) rises, with no particular dispersion occurring within a particular class of food/establishment and certainly no increase in dispersion as competition increases. On the other hand, the price of wines may

[4] Clearly, the elements of costs that we capture are those at market level; however, we would argue that the opportunity cost of providing a wine in a meal is the price that the bottle could fetch on the auction market, which was already worldwide at the time of this data exercise and certainly is now. Information on the current auction price, while widely available, could be costly to check frequently in itself. This further cost of finding the auction price and updating the menu may result in very "sticky" wine menu prices.

[5] While we solve in this version for the case where all customers purchase wine, allowing a portion of the public not to drink does not substantively change the results because it simply removes some consumers from the population we study. This could, however, affect the magnitude and parameter ranges where the results hold.

[6] A new, identical, population of tourists enters in the following period.

not fall, and may exhibit increasing dispersion as the level of competition (density of establishments) rises.

The intuition for this increasing dispersion is multi-faceted. The direct effect of increased competition causes its price to fall to tempt repeat customers away from competitors. There is also an indirect effect, however, which goes in the opposite direction. Even if two restaurants select the same wines for their wine list, each wine may play a different role at different establishments. For some, it may be targeted at "tourists" while in others it may be targeted at "connoisseurs". As restaurant density increases, competition exerts pressure on the posted portion of the meal price – the food. This decreases the total bill that a restaurant will charge to the customer. This means that as the food price falls, the pressure to reduce wine price as well to obtain customers for the "full meal" is reduced. This effect does not come into play for a bottle directed at tourists, but it does affect bottles – even if a bottle of the same wine – directed at connoisseurs. If this effect is strong enough, the indirect effect going through the food bill to the wine pricing can dominate, resulting in increased wine price dispersion. The balance of the wine and the food in the total margin of the restaurant determines whether the indirect effects we have mentioned are strong enough to generate a positive relation between price dispersion and competition: for price dispersion in wines to increase with competition among restaurants, food must carry sufficient "weight" in the bundle of goods that is consumed in a meal. Furthermore, repeat purchase must be sufficiently important to the restauranteur's pricing decision for the non-posted wine prices to be used to manipulate consumer behaviour.

Existing models of price dispersion are not well adapted to the market we study. Most focus on the sale of only a single good[7],whereas the sale of wine generally accompanies a meal, which acts as the "base good" to the wine's "add on". Indeed, similar to "add on" models, the wine price often is not known until the customer sits down at the table to order, whereas the food portion of the meal acts as a "base good" carrying a price that is known (often posted outside the restaurant). This mixed structure of announced and unannounced prices is present in Lal and Matutes' (1994) and Ellison's (2005) treatments of add-ons, but they do not study price dispersion's relation to competition, nor do they allow for a menu of add-ons (the wine list), as we do here and as is common in restaurants[8].

The mechanisms explaining the relationship between price dispersion and competition vary considerably across the literature. Just as we do, Syverson (2007) relies on a spatial model of competition but focuses on a single good. He finds that competition decreases dispersion as

[7] For a wide ranging review of the literature see Kaplan et al (2019).

[8] In contrast to us, Lal and Matutes (1994) allow for multi-homing and a single type of customer. Again, in contrast to us, Lal and Matutes (1989) allow for multiple customer types but assumes full information on prices.

higher cost firms drop out of the market[9]. Aside from our contrasting empirical results[10] and our "bundled" product, our understanding of the opportunity cost of wine is that it does not differ a great deal across restaurants: all have access to reselling their bottles on public auction sites, and these appear to carry similar prices for similar bottles. Hence, the assumption underlying Syverson's model that opportunity cost varies across providers does not hold here. We look elsewhere, then, for the underlying cause of our observed behaviour.

Verboven (1999) studies the relation of price dispersion to competition both empirically and theoretically, finding that dispersion increases with competition. Like us, he studies add-ons in the sense that the price of a feature is not necessarily known before visiting the outlet. In contrast to our approach, however, his model collapses the offer at each outlet into a single high value or low value product where the high value product has add-ons incorporated. As a result, the interplay between the bundle's components that generates dispersion within the add-on portion of the bundle, present in our story, cannot arise in his model. Furthermore, his model allows consumers to "shop" before they buy. In our case, consumers must purchase wine at each restaurant meal and consume at a restaurant in each period. In other words, even if a customer selects to learn, she must consume in order to learn rather than learn and then decide not to purchase[11]. Restaurants take this into account, as do consumers, in their pricing strategy. The difference between the two modelling approaches reflects differences in the underlying market studied: car dealerships in Verboven's case; restaurants in ours.

Prices of wines tend to be quite stable in different outlets over time in our sample with about 70% of wine prices not changing at all and others changing quite modestly by and large. This is at odds with the predictions from a model with a mixed strategy equilibrium, as is typical of many papers in the literature on price dispersion and search, or models working through "stock outs"[12]. Even within the literature on search that is compatible with stable prices, the underlying assumptions do not square with the institutional framework, including our

[9] Interestingly, Gerardi and Shapiro's (2009) critique of Borenstein and Rose's (1994) results on price dispersion as a result of price discrimination also generates prices falling from above as competition increases, suggesting that perhaps cost differences may be at play in the market for airline ticketing as well.

[10] Syverson's (2007) finding that a competition increases price dispersion falls from above does not hold in our data. See later in the paper for discussion.

[11] Dai, Liu and Serfes (2014) present a similar model, deriving an inverted U shaped relationship between competition and dispersion across quality categories. We, in contrast, examine dispersion within the add on and within quality categories (indeed, the theoretical model examines dispersion within a single product). We do address quality effects later in the paper, however.

[12] See Stahl (1989) and Pennerstorfer et al (2020), for example, who model differences in information that generate price dispersion for single goods, and relate this to competitive pressures, finding a non-linear relation. These models feature mixed strategy equilibria, however, and so fit other types of markets better than ours. Pennerstorfer et al(2020) and Lewis (2008) examine gasoline sales, documenting that there are frequent relative price reversals in this market. Other contributions to search with multiple products include McAfee (1995), Baughman and Burdett (2016), Rhodes and Zhou (2015) and Zhou (2015). The stable prices we observe are also at odds with inventory models, which predict price changes at "stock outs" and with sales (see Butters, 1989, and Varian, 1980).

emphasis on pricing effects within a bundle[13]. Indeed, our work does not focus on the search aspect of purchase but rather on matching heterogeneous consumers to heterogeneous restaurants in a situation where sampling is sequential and can carry a cost but also generates profit for the outlet[14].

Closer to our modelling framework, Kaplan et al (2019) study retail markets where prices tend to be stable over time and where multiple goods are purchased in combination. That model combines search and price discrimination to derive price dispersion in a market that is highly competitive. In their framework, consumers are heterogeneous: some with a high valuation of the goods are restricted to purchasing the bundle at a single outlet. High valuation customers are "busy" people who do not have the time or desire to shop around and hence purchase the bundle from a single outlet, while "cool" customers have lower valuations and can purchase a single item at one outlet and the second item elsewhere. Furthermore, some buyers have access to the prices of a single outlet while others have access to the prices of several. The combination of heterogeneity in information with search frictions means that there is an opportunity for price dispersion. Heterogeneity in valuation means that there is an incentive to price discriminate. The price of any single component of the bundle varies, as it is in the interest of any one outlet to price its component differently from any other to avoid head-to-head price competition in that component. The combination of these generates the market level price dispersion that they observe[15].

While we, like Kaplan et al (2019), wish to capture persistent price dispersion in a market with relatively stable prices, we adopt a very different modelling approach to fit the features of our market. While "busy" and captive customers are a good assumption in retail markets it is less compelling for full-service restaurants, which generally would be enjoyed at leisure rather than being viewed as chores that need to be done quickly. The price structure in restaurants also differs, as the wine price often is not observed until the customer commits to the restaurant, although the food price often is. Finally, we study a case where the base good (food) can be paired with a choice of add-ons (wines), one of which is selected from a menu upon arrival at the outlet, not that there is a unique pair that may be purchased at different outlets. Hence, while we derive a price dispersion equilibrium in a model of multiple products and where price levels are persistent at individual outlets, we do so in a model that is complementary to theirs and better adapted to restaurants. We also note that, although our data set does not allow us to test this aspect of pricing, our model offers a different

[13] For example, classic contributions of Burdett and Judd (1983) focuses on a single good and, where sequential search is undertaken, it is noisy.

[14] Zhou (2017) studies oligopolistic bundling with varying match quality, similar to our possibility that the wine list at a restaurant is more compatible with one consumer than another, but does not consider non-posted prices as we do or examine within-bundle pricing strategy. See also Choi et al (2018).

[15] Relative price dispersion, as studied by Kaplan et al (2019), has been studied in homogeneous consumer contexts in a series of earlier papers where the intuition is not price discrimination and multi-stop shopping is an option. See Zhou (2014) as a recent example of this stream and literature review within.

prediction for the degree of dispersion observed for each of the products. Translated to the restaurant market, the Kaplan et al (2019) model would predict that the degree of dispersion of food and wine would be the same[16]. Our model implies that there should be more dispersion in the prices of add-ons (wine).

Empirically, while price dispersion in wines has been studied (Jaeger and Storchmann, 2011) at the retail level, studies of price dispersion in restaurants have not examined wine pricing, as they have concentrated on fast food outlets[17]. Restaurant meals are interesting to study because they are complex: a restaurant experience involves food, beverages, and an experience of décor and service. It is often enjoyed as part of a group. Furthermore, the time pressures and lack of attention that might surround retail sales of high volume and low value goods may not be present as a restaurant meal is often taken at leisure.

Our model makes several contributions.

First, understanding pricing in the restaurant sector matters, although it has not been researched very intensively using economics modelling. Restaurant meals are becoming increasingly important as a share of household expenditure, surpassing the expenditure on eating at home for the first time in 2010 in the US. Full-service restaurant meals away from home increased to between three and four percent of US household budgets in the years to 2010. In the UK, household food expenditure has followed a similar pattern, although expenditure on meals outside the home is lower at about 34% of the total food budget[18]. As younger demographics exhibit a more pronounced trend toward outside eating, this pattern is likely to continue. Our study contributes to this understanding empirically by characterising pricing behaviour in a model that captures both the overall bundle pricing and allows us to comment on how this varies with competition.

---

[16] See Lemma 3 in the Kaplan et al paper, but also note that this is normal due to the different observability of prices in our framework. Also related to our work is a much earlier paper by Lal and Matutes (1989), who study relative price dispersion in a spatial model of multiple goods, as we do. Their model is directed at the retail segment as is Kaplan et al (2019), since consumers can "shop around" to consume one product at different outlets, assembling their desired bundle after patronising several shops. They have a similar "busy" and "cool" set of customers to Kaplan et al (2019). Our approach is, then, also complementary to their work.

[17] See Lafontaine (1995) for price dispersion working through franchising contracts or company owned arrangements in fast food outlets. Our restaurants tend to be independents, so her mechanism does not apply.

[18] For information supporting this set of figures, see USDA Economic Research Service: America's Eating Habits: Food Away From Home, EIB-196, By Michelle J. Saksena, Abigail M. Okrent, Tobenna D. Anekwe, Clare Cho, Christopher Dicken, Anne Effland, Howard Elitzak, Joanne Guthrie, Karen S. Hamrick, Jeffrey Hyman, Young Jo, Biing-Hwan Lin, Lisa Mancino, Patrick W. McLaughlin, Ilya Rahkovsky, Katherine Ralston, Travis A. Smith, Hayden Stewart, Jessica Todd, and Charlotte Tuttle Edited by Michelle J. Saksena, Abigail M. Okrent, and Karen S. Hamrick, September, 2018; available at: https://www.ers.usda.gov/webdocs/publications/90228/eib-196.pdf; also Okrent, A., and Alston, J. "The Demand for Disaggregated Food-Away-From-Home and Food-At-Home Products in the United States", ERR-139, USDA, Economic Research Service, August 2012 and flexible consumer behaviour survey results from the USDA, summarised at: https://www.ers.usda.gov/topics/food-choices-health/food-consumption-demand/flexible-consumer-behavior-survey/

Second, price dispersion has long been recognised as an important concept to understand, and while many models exist of dispersion, many also consider only a single good. This is true even where often multiple goods are purchased at the same "stop", as is pointed out in Kaplan for retail, but could be extended to many other settings where modelling simplifies to a single good. We develop a model that more generally allows us to study the effects on price dispersion and competition of the interaction of the elements of a complex good, when the prices of the good's components are not observable at the same time. This framework is distinct from the approach taken to price dispersion in retail settings and so both adapts our framework to our market of interest and introduces a distinct intuition. Add on goods are common across many markets, and so improving our understanding of the pricing implications is important to understand general price patterns. Hence, we mesh two recent strands of work to study how they interact, using a particular market as an example.

The paper is organised as follows. Section 2 outlines some special features of the market we wish to study and how we propose to approach the estimation. Section 3 presents our dataset and our basic empirical results. In section 4, we present our theoretical framework, with the intuition for and main results on price dispersion of wine as competition increases. Section 5 discusses both robustness and more detailed results that can help reassure us that our explanation may indeed be well suited to this market. Section 6 concludes.

2: Restaurant Consumption of Wines

We turn first to institutional information about wine purchase and consumption to justify our modelling strategy and assumptions. This is relevant to the set of controls we use in the empirical section as well as the underlying assumptions of our theoretical model.

Restaurant meals are complex products in both composition and pricing[19]. Meals include both food and beverages, in most cases, and in full-service restaurants include waiter service, and sometimes sommelier and other services as well. The pricing of these various elements may be itemised. Meals with several courses and matched wines may be an option for a bundled price or meals may be purchased "à la carte" with wine purchased separately or not at all. Prices for some but not all of these elements may be publicised, with a common pattern that the (priced) wine menu is available upon entry and commitment to a table (ie, sitting down) for at least one person in the party while the price for the food menu may be more easily accessible outside the restaurant on the street or on a website. Indeed, the restaurant experience may well involve a stroll through a city centre searching for an appealing combination of menu, décor, and location or alternatively may involve returning to an

[19] See De Silva et al, 2013, "Restaurant Wars", U. Lancaster Management School Economics Dept Working Paper 44312700, for a summary of a number of strands of research.

establishment that is known to the consumer, who seeks the repetition of a familiar but pleasant experience[20].

Consumption at a full-service restaurant generally is not a frequent, low value affair undertaken under time pressure: it is more likely an enjoyable portion of leisure time. The "inattention" by either staff or customers that one might see in some retail food purchases might not therefore be a leading cause of price dispersion. While not denying that either inattention, mistakes, or other issues may result in this price dispersion, it is not clear how dispersion rooted in inattention or mistakes would depend on the level of competition in the market[21], which is our focus.

Wine pricing has been noted as complex, but equally as extremely important to the success of the restaurant (Russell, 2009, cited in Siriex). Siriex et al (2011) review not only the factors affecting wine menu pricing but also the variety of strategies adopted by restaurant managers in selecting wines to serve customer needs. Popular press articles note heterogeneity across customers in the criteria they use to select wines, running from regional preferences to a fixed budget (Morssglobalfinance and qz.com websites)[22].

Not all customers drink. In recent years, the percentage of the US population reporting complete teetotaling stood at 13.7% (NIH, 2015) and in the UK at 20.4% (ONS, 2017). This still leaves plenty of people who do wish to purchase alcohol, some of whom fall in our group of interest as wine drinkers in restaurants. There is no evidence that teetotallers enjoy their dining experience less than drinkers. As they form a substantial proportion of the dining public, we comment on their inclusion in our theory section, below, even though they are not a focus of our work.

Within the drinking population, purchasing wine is a complex process that has been the subject of intensive observation and research by industry experts. Wine is an experience good. Quality signalling is, then, crucial to the purchase; however, wine labels often contain

[20] While academic literature has emphasised the importance of customer retention to profits (see Gupta and Zeithaml, 2006), this is also the case in practitioner-oriented work. Harvard Business Review has covered the importance of customer loyalty to a number of business types over the years, such as Reichheld and Sasser (1990) and more recently with Reichheld and Schefter (2000). This has been brought to the restaurant industry in industry publications, such as Resendes (2020).

[21] The importance of wine pricing strategy to restaurant profitability is emphasised both by academic work (such as Livat and Remaud, 2018) and in the popular outlets that give advice to restaurants such as SommelierBusiness.Com. (See for example https://sommelierbusiness.com/en/articles/menu-intel-1/wine-pricing-strategy-profitability-and-adjustments-14.htm accessed 11 March, 2020.)

[22] Combris et al (1997) study market pricing (not restaurant pricing) and quality ratings of Bordeaux wines in a hedonic pricing model. They find that "objective" characteristics on the label do a good job of explaining price but that tastes determine quality ratings and are heterogeneous so that no "definitive" quality emerges. We use "objective" wine characteristics as controls in our first stage hedonic model, following this lead. . We model the drinking population as heterogeneous in our theory to reflect these and other similar findings. Oczkowski (1994) uses a similar hedonic method for Autralian wines but does not include sensory characteristics. Benfratello et al (2009) find that reputation, more than sensory characteristics, contribute to the price of Italian wine. Vintage/chateau controls are included in our regressions, and reputation is likely to be reflected in those variables. See also Roma et al (2013) for hedonic results on Sicilian wines.

so much information that their interpretation as a signal can become muddied for boundedly rational consumers (Barber and Almanza, 2007). Experience can improve the take-up of label information, even if novice consumers use price as their main guide. On the other hand, experienced consumers may use most of the cues given by labels (Lockshin *et al.*, 2006). As the industry is composed of extremely diverse and small producers, even those who know a great deal about wines find perfect information pre-consumption elusive when presented with a new wine list (Chaney, 2000). Indeed, it is usual for consumers to stop searching once they have found one or several (interpretable) characteristics that fit with their expectations (Dodd *et al.*, 2005). We simplify this heterogeneity by postulating two groups, "tourists" and "connoisseurs", who differ by knowledge, ability to discriminate among wines, and likelihood to change outlet based on the wine price list.

Furthermore, because the wine quality is a mix of objective and subjective considerations and a highly differentiated good, consumers' heterogeneous preferences play a significant role in the wine purchasing process. Expert opinion is available for many wines and may supplement the consumer's own judgement; however, significant variability in expert ratings of wines is well documented in the wine research literature. For instance, Oczkowski (2017) studies 258 commonly assessed premium Australian wines and finds considerable variability in ratings. He also documents that this is not unusual: findings from the literature carry Pearson correlations in five studies varying from .11 to .58, with an average of .34. For Bordeaux wines, this is somewhat higher at .60. Ashenfelter and Jones (2013) show that expert scores on Bordeaux wines can be particularly poorly correlated with prices in years with bad weather as they tend to transmit only publicly available information rather than more specific information that affects taste. For Bordeaux wines, Cardebat and Paroissien (2015) reveal a high variability in the experts' scores, which goes well beyond any difference in scales of notation (20 points vs 100 points)[23]. Moreover, the expert judgments have been called into question by numerous studies, both in terms of reliability and consensus (Hodgson, 2008; Cardebat *et al.*, 2014; Cao, 2014; Stuen *et al.*, 2015). Summarising the state of expert guidance on wines, Robinson (1997) notes that "individual wine consumers are better off, my argument goes, following an individual wine critic's preferences and prejudices and getting to know how they relate to their own…" [cited in Oczkowski, 2017]. To capture this disagreement, we model consumer (and possibly restauranteur) tastes as heterogeneous in the sense of horizontal differentiation, below, with no uniform quality ranking of wine.

Outside of the sphere of oenologists, consumers also have significant variance in their own quality ratings of wine. Experiments have shown the inability of wine drinkers (novices or connoisseurs) to recognise the same wine when they drink it twice in a same blind tasting (Goldstein *et al.*, 2008; Almenberg and Dreber, 2011). Brochet and Morrot (1999) also stress the crucial influence of context for the wine quality assessment and this finds its way into our

[23] The web site Global Wine Score (see https://www.globalwinescore.com/) offers a wide range of examples of this variability by displaying all the scores of the main critics for each Bordeaux *en primeur* wine.

empirical work[24]. Scraping the website Vivino, (Kotonya *et al.*, 2018) also shows a dispersion in the ratings and identifies some biases linked to a home-effect and toward the French wine style. This suggests that, while experts may be quite heterogeneous in their quality assessment of wines, so are consumers and restauranteurs. Indeed, this suggests that consumers who are looking for an enjoyable bottle of wine to accompany their meal could well be influenced by and possibly benefit from the "right" sommelier or restauranteur as part of the matching process. The matching of the wine with food is also of a great importance for avid wine drinkers (Jaeger *et al.*, 2010).

Restaurants do not generally post their wine list for consumers to study before choosing the restaurant. More often, consumers view the food menu, enter the restaurant, and then choose (or decide not to choose) a wine to accompany their meal, often with the advice of the sommelier or restauranteur, especially in the fine dining establishments[25]. The presence of specialized staff can reduce the perceived risk when choosing wine (Lacey *et al.*, 2009). Women are particularly sensitive to staff advice (Atkin *et al.*, 2007). Wine is nonetheless important to the selection of restaurants: amateurs can choose a restaurant based on the proposed wine (Brown and Getz, 2005; Croce and Perri, 2017). Based on these findings, it appears that some consumer groups use wine as a major determinant of patronising and returning to a restaurant. Indeed, restaurants (especially upscale) design the wine menu to differentiate their supply and to attract new customers and/or to enhance customer loyalty (Berenguer and Ruiz, 2009). In what follows, we model the wine menu as a major determinant of choice of restaurant for some customers; however, we do not model the sommelier's function explicitly, relying rather on our restaurant controls to capture this and other aspects of "context".

Summarising this brief review, we conclude that our model should be characterised by heterogeneous quality rankings of wine across restauranteurs, and equally heterogeneous quality rankings across consumers who are wine connoisseurs. Connoisseurs can detect differences among wines and seek out preferred wines, even though other customers are relatively indifferent to wine characteristics other than price. The restaurant's selections of wines to match certain types of customers may differ across restaurants. We require all consumers to purchase wine in our basic model, although we recognise that teetotallers may be present and discuss the effect this might have on our results in our robustness section. Finally, we allow for a segment of the market that may repeat their purchase, even though some customers are only short-term members of the market. We allow this repeat purchase to potentially play a large role in the restaurant's decision making.

[24] We introduce controls for the type of cuisine as well as location and other context variables in our empirical work, below. We do not, of course, have information on the guests at the table.

[25] We take as given in our model that the wine price is not posted, but appeal to Armstrong (2017) and his summary of the literature to claim that this assumption can be justified within the literature on the benefits of raising search costs. Anderson and Renault (2000) also support this view.

While restaurant meals are complex products, we model them as a bundle of two components, food, and wine, and study the pricing of these two components. Hence, we collapse all other elements of service into restaurant fixed effects that are not our focus. Information on the selection and pricing of wine is only available upon entry and commitment to the restaurant, endowing it with one element of an "add on" good but also allowing the learning that evidently occurs in this market before the customer repeats their decision to purchase another restaurant meal.

We turn now to our empirical analysis.

Section 3: Empirical Analysis of Price Dispersion in Wines

This section establishes the basic empirical relations that we wish to explain. We will return to the empirical analysis in more detail after we present the theory to investigate how the theory can speak more precisely to the data.

We follow a two-step procedure, which has become relatively standard and is present for example in the papers of Sorensen (2000), Lach (2002), Lewis (2008), Dubois and Perrone (2015) and Pennerstorfer et al (2020), among others[26]. We first clean the data of as much heterogeneity at the product level as we can, then we use the residual variance in prices as our measure of price dispersion[27]. In this second step, we regress this price dispersion on explanatory variables to see how it behaves as we modify the degree of competition in the market, also controlling for a measure of income differences to capture demand-side elements of price changes.

3.1 Data

Our sample is composed of information collected by Wine Data Services[28] on distribution data for major consumer markets. Among other data they collect, Wine Data Services audits restaurants yearly in the Americas, Europe, and Asia. This audit includes a photograph of the menu, which is then used to build a database on which wine is sold at each establishment, and at what price. We observe only availability and posted price on the wine menu, not transactions.

From this, we extract a sample composed of 9668 distinct wines (brand - vintage pairs) just over 900 restaurants that sell the wines by the bottle and a total of almost 70,000 observations. We concentrate on five major cities that form part of this survey: Paris, New York, Los Angeles, London and Hong Kong and three (yearly) survey periods from March, 2011

[26] See the last two of these references for extensive reviews of the literature.
[27] This is not the only method we could use. For example, see Pennerstorfer et al (2020) for discussion. We have investigated Pennerstorfer's "value of information" measure in two of his formulations – one measuring the difference between (residual) price and minimum price; the other using average price. We do not observe any substantive difference in the results, and so only report the "variance" measure here.
[28] See: https://winedataservices.com/

to December 2013, where each city is visited twice during the time period.[29]. These are summarised in table 1, below:

Table 1 here

All restaurants are sampled within a given month, and we give dummies for the survey month, so seasonality should not be a concern. Our observations are relatively evenly distributed across these cities and generally we have about a third of all data in each of the three years, as shown in table 2.

Table 2 here

Our measurement of wines allows us to be quite specific on the bottle down to the colour and type of the wine so that if a single chateaux sells several different types of wine such as a red and a white, these show up as different wines in our data. For each wine, we know the restaurant or bar where it was sold, including the exact GPS location of the sale, and a descriptor of the ambiance of the location and cuisine, for example whether the cuisine was "French" and style was "fine dining" or "brasserie". A very small part of the venues, at less than 2%, was classified as a "bar" or a "wine bar", where wine might be the main item that is consumed. These are identified by a dummy variable in the analysis or eliminated. Most, however, are eating establishments in the first instance, and we focus on this case.

We also have a descriptor of the quality of the outlet, including the Michelin Stars and the quality of the wine list, as judged by Wine Spectator. These will not be a focus of our theoretical modelling, so we include them in the empirical model as controls and only comment briefly on the related results. Our quality measures come in three levels (one to three stars for Michelin and three levels of excellence for the wine list: "award", "best", and "grand award"). This gives us a more formal ranking of quality than has been included in some other work on price dispersion, such as Lewis (2008), where the judgement of quality is *ad hoc* and possibly could reflect other elements than quality[30]. We assume that consumers interpret this rating as the quality of the wine list taken as a whole, not that of an individual

[29] Each city is observed over two years, so each city has two census periods (different years for different cities, because not all cities are visited in all years). Many wines are not observed very often, given this, nor are all wines sold widely. We remove from the final regressions cases where wines were not sold in multiple establishments, as our eventual model will look at pricing where sales are competitive.

[30] Lewis appeals to Hastings (2004) to suggest that brands with high market share are those with highest quality for his data, based on an assumption of brand loyalty where brands are viewed as superior.

wine[31]. Michelin stars generally refer to the quality of the food and setting rather than the wine[32]. In contrast, the Wine Spectator awards are based purely on the evaluation of the wine list, including an evaluation of depth across regions and "quality levels" (which tends to be correlated with length), match to the menu, thematic quality, and presentation. Service is also part of the rating, for example the assistance given to diners at the point of wine selection. Michelin Stars and Wine Spectator ratings are quite constant over time in our sample.

The data reflects significant skewness, illustrated in Figure 1. Some of these are best to eliminate in order to avoid excessive outlier effects, among other reasons. Wine sold by the glass is removed as are excessively small or large sized bottles. This leaves three sizes of bottle in the final analysis: 75 cl (our main interest), magnums and half bottles (dummied). We eliminate wines of a vintage older than 1945 to avoid sales of bottles that are possibly kept for "exhibiting" (on the menu or otherwise) rather than drinking. Finally, we eliminate outlets that have more than a single wine menu, such as an outlet that has both a main restaurant and a brasserie.

Figure 1 here

Descriptive statistics of the prices in the five markets are presented in table 3, below. Despite the winnowing, skewness remains and the minimum and maximum prices give a sense for the enormous variation in a price of wine – overall – in all markets from a minimum of 9 euros to a maximum of 28,026 euros.

Table 3 here

The final sample of 60,137 observations continues to include "everyday" wines as well as highly iconic wines[33]; the restaurants include those that do not receive any Michelin stars or awards for their wine lists as well as three starred restaurants with grand awards of excellence

[31]We assume that the consumers (and restauranteurs) view wines as horizontally differentiated, but the wine list that is available to choose from may well be classified by an external organisation as "better" or "worse". As would be expected, an element of this quality is the length of the wine list, which we have studied separately in our regressions as it has interest in its own right. Different rating systems also include other characteristics, however. What is more important for us is that the quality "label" is affixed to the restaurant, however quality is judged. We assume only that consumers know these labels and view restaurants with a different label as distinct (at least before they purchase).

[32] Michelin does not disclose the specifics of its rating system, but is focussed on food, see http://www.telegraph.co.uk/foodanddrink/10337149/Inside-the-secret-world-of-Michelin-restaurant-inspectors.html

[33] We separate out the iconic wines from the rest later in the paper, as these groups may potentially have different behaviour. See section 5.

for their wine lists. Hence, strengths of the final sample are its specificity, its size, and its variation[34].

Wine pricing in restaurants is generally described both in the popular press and in professional training documents as a rule of thumb markup over some measure of cost, often stated as retail (resale) price.[35] We have information on the current retail price for each bottle and can check the markups to illustrate this rule. As an example, we show the prices and measured markups for five iconic bottles of 1961 vintage across our five markets in Table 4. The markups vary from negative numbers in a few cases to four and a half times, as multiples of "marginal cost". The ratio across the markets of the price charged is substantial – over three times for some. On average, however, they are in keeping with the 2-3 times mark-up that is the "industry standard" according to the trade publications in the area. With prices very "sticky" in our sample and retail price higher than our conception of opportunity cost (auction price), it may be unsurprising that some margins are negative. As restaurants all face the same auction prices for bottles as an alternative to sale, and we are interested in price dispersion rather than price level *per se*, we are able to use price rather than margins in the work and still draw conclusions that should carry over to margins[36].

Table 4 here.

Each observation is a single wine (chateaux, type, and colour), a vintage, a location (city and restaurant), and a time during one of three census periods.[37]

3.2 Method

We mainly are interested in measuring the price dispersion of these wines across outlets, although we also observe and comment on the dispersion within outlets. Clearly, some of this dispersion comes from the conditions of sale (restaurant, city and time period characteristics, for example) and some comes from differences in the wines across vintages and makers. As price dispersion would normally refer to dispersion within an undifferentiated good, our first step is to remove heterogeneity to retain only the portion of the total price that is associated with the underlying homogeneous product.

---

[34] Small differences in the number of observations when totalled across cities or Michelin/non-Michelin outlets are due to a small number of non-identified observations. We have not eliminated these from the overall total, but they are eliminated in the city-by-city (or smaller) units of analysis.

[35] Retail price is not our conception of opportunity cost: that would be auction price, which would generally be lower.

[36] We use prices rather than margins in our regressions. While do not have complete information on auction prices for our full dataset, we have checked auction versus menu price and find negative margins rare, if existent at all. . Since all producers face the same auction price, and since we look at dispersion at the level of individual wines, subtracting a common marginal cost from all the prices is possible (and we have performed this exercise to check), but does not affect the main results.

[37] For example, an observation would be "Château Pontet Canet, 5th Growth, Pauillac, 2003 sold at Cafe Boulud, in New York City, February 2012"

Hence, our first stage focusses on isolating the points of differentiation and removing these. Clearly, this is a challenge for such a diverse dataset. Fortunately, hedonic pricing studies give us a guide to what matters to price and indeed our percentage of variance explained at the first stage is high at about 92%. The richness of the dataset allows us to introduce an unusually wide variety of fixed effects to control for the restaurant, vintage, wine, aspects of the wine such as colour, location, and time (census date when the survey captured the contents of the menu) of purchase. This should result in a "stripped" or "homogenised" price. We can then measure the dispersion of this residual and correlate it with competition (or other variables of interest) in the second stage.

In a nutshell, while in the first stage we regress *price level* against as many characteristics as possible of the *bottle itself* and its conditions of sale, in the second stage we study the stripped *price dispersion* against features of the *market.*

We do this by following the two-step procedure that has now become standard, following references cited above. It is also standard to comment that the technique introduces a potential source of bias by the method of removing heterogeneity: if the functional form is mis-specified then there is a potential bias introduced in the shape of the price residuals that we analyse. As a result, we experiment with alternative specifications, but do not find compelling evidence that the linear model performs badly in this case[38].

More precisely, we model price as a linear function of a vector of independent variables and an error term. The variables we include try to remove the main sources of heterogeneity that we would expect across outlets that sell the same wine. We estimate this first stage by means of ordinary least squares, with right hand variables specifying a series of fixed effects capturing the Chateau name (i), the vintage of the bottle (j), the restaurant (k), the time period (t) of the sale as measured by the census date of the survey of wine lists, the size of bottle (75 cl is the reference category) and the colour of the wine ("sweet" is the reference category, with other categories being red and white). A constant and error term complete the specification. We assume that the error is heteroskedastic.

$$P_{ijkt} = \text{f(Wine, Restaurant, Vintage, Bottle type, Census date)} \qquad (1)$$

$$E(\varepsilon_{ijkt}) = 0$$

$$Var(\varepsilon_{ijkt}) = e^{\alpha z'_{ijkt}}$$

As the R^2 is quite high but the coefficients in themselves are not of much interest, we suppress these results for brevity. Instead, we move on to investigate the correlates of the error variance in the second stage. The second stage uses $\log(\hat{\varepsilon}^2_{ijkt})$ as an estimator of $Var(\varepsilon_{ijkt})$,

[38] We have investigated non-linear and linear specifications and various error terms structures. These do not change our basic point, and indeed the coefficients on the non-linear terms are insignificant and small. In the face of no evidence that alternatives to the linear specification improve on the accuracy, we eliminate these alternatives for brevity .

which we take as the price dispersion of the "cleaned" prices. We regress this on the set of explanatory variables, z[39].

Our relation of interest is the link between our proxy for dispersion and competitive strength. We do this by relating dispersion to a measure of restaurant density, specified as the number of different restaurants in a city area that offer a particular chateau's wine on the menu ("density" in the regressions below). The density and the dispersion measures are both at the wine level, which will find a parallel in the theoretical model, below, where dispersion increases with competition at the level of the wine and also at the level of the market for all wines taken as a whole. Our underlying assumption for the specification at wine level is that wine drinkers search for the chateau as the main feature of the wine, not the specific vintage[40].

We share our measure of competition with Lewis (2008) and Pennerstorfer et al (2020). We observe first that there is no particular relation between the stripped wine *price* and density: the relationship appears quite flat, in fact, with an almost nil R^2. [41]. This is true when we repeat the regression measuring density at the neighbourhood level and using one alternative measure of competition that weights all outlets within the urban area by their distance from the point of sale of the wine in question[42]. This can be seen in Table 5. While we do not want to rely much on this result, as we have not instrumented to control for endogeneity of the relationship between price level and competition, the direction of the relationship will be interesting for the later discussion As there is no difference in the relation at any geographic level, we are at least somewhat comforted that we have removed any agglomeration effects

[39] This follows the multiplicative heteroscedasticity model of Harvey (1976). Note that some papers such as Lewis (2008) use prices in the first stage and take logs in the second stage, whereas others, such as Dubois and Perrone (2015) use the log of price in the first stage. We have pursued the former strategy. The importance is to have logs taken of some version of price, as thisallows us to take some account of the skewness of the distribution. Other measures of dispersion, such as a Gini coefficient have been used in place of variance by others, see Dai et al (2014) and our comments on alternatives in footnote 27.

[40] We enter a value of "1" if a wine to indicate that the restaurant offers the wine on the menu, but do not change this value if, for example, several vintages of a wine were available. Hence, each increase in density requires that a different restaurant offers the wine. We have also tested for an effect of competition within ambiance or cuisine category to proxy searching for cuisine style first and then wine availability by using the density of wine outlets within cuisine or ambiance categories. This takes into account that our theoretical model is (implicitly) examining wine prices for food that is undifferentiated. Even though our first stage has a fixed effect to strip wine prices of such differences, this does not mean that consumers consider all outlets when they look at the travel cost to alternative sources.

[41] We should not, in fact, see the sort of "artefact" dispersion that is noted by Dai, Liu and Serfes (2014), where increased competition reduces dispersion directly by lowering average prices, where they use a Gini coefficient to measure dispersion.

[42] We use radial distance, assuming that restaurant-goers can reach their chosen restaurant by many means and that the cities where they are located are not systematically subject to barriers to movement in any direction. Indeed, even cities in our sample like Hong Kong, which faces large natural barriers, have excellent transport linkages specifically designed to overcome these. We do not, however, know the true shape of transportation costs: indeed, we would expect that these would differ across cities. Further, we do not consider non-distance related barriers, such as neighbourhoods where some consumers would hesitate to go for security reasons. While this is a possible consideration in the US in particular, the restaurants we study are sufficiently "classy" that they do not locate outside of well frequented areas.

from the prices. Further, since the stripped prices are quite "flat", we do not see that the measure of dispersion will suffer from the objections raised by Dai et al (2014) where their price levels change systematically, creating changes in dispersion as an artefact[43].

Table 5 here

We now turn to our main interest: an investigation of the *dispersion* of "stripped" price, the variance in the error of the first stage regression, and competition, the density of outlets providing the same wine. We add a number of covariates at this stage, which will have some interest in their own right as determinants of dispersion. These are no longer individual wine fixed effects, but instead include more general features including the type of cuisine/ambiance of the restaurant ("Type"), the quality ranking of both the restaurant – measured in Michelin stars ("Stars") – and the wine list – measured by Wine Spectator awards of excellence ("Award"). We also examine the length of the wine list as a separate indicator, although it is correlated with the excellence award ("Length") and bottle size. Time dummies continue to be included and city identifiers are used to break out the results by market. Restaurant fixed effects reflect the location of the outlet to correct for any demand-side features such as the income of the local area, although we have no reason to expect that this is playing a large role (see Table 5). We do not instrument in this equation, as there is no necessary connection between dispersion and competition, even though this was not true for price level[44]. Hence, we do not add the caveat we included for Table 5.

The final form of the second stage regression is, then:

$$\log\left(\hat{\varepsilon}_{ijkt}^2\right) = \alpha + \beta_1 Spatial\ comp. + \beta_2\ Wine\ list + \beta_3 Awards + \beta_4 Bottle\ size + \beta_5 Restaurant\ type + \beta_6 time\ +\ \varphi_{ijkwst}$$

Where the last term is a normally distributed error term. The results are reported below, with standard errors clustered at the restaurant level:

Table 6 here

To ensure that our results are not sensitive to the precise specification of either dispersion or competition, we perform various experiments with different proxies. For dispersion, we use two different measures of the value of information from Pennerstorfer et al (2020), the difference between the price of a wine at a given outlet compared to the minimum price available and the difference between the price and the average price for that same wine in the market. For competition, we experiment with an aggregate measure that combines

[43] Da Silva et al (2013) find that fine dining food prices rise with density at neighbourhood level and fall at city level. While we find no difference in the (nil) relation of stripped price to density at any geographic level, we note that this is not the raw price, which can behave quite differently. It does comfort us, however, that we have removed agglomeration effects from the stripped price level. For Dai et al (2014), see footnote 41.

[44] While Gerardi and Shapiro (2009) instrument, Pennerstorfer et al (2020) and Lewis (2008) do not. As we do not see the argument for endogeneity in dispersion as compelling, and instrumentation carries some drawbacks on its own, we do not pursue this route.

distance to all outlets for the same wine and a measure that restricts competition to be within either cuisine or ambiance category. We also experiment with non-linear versions and cross effects. The flavour of the results remains with these (and other) variations. We will retain the main results only for the purposes of discussion.

3.3 Results

Our main interest is in the coefficient on density. We see significant positive effects of an increase in density of points of sale for a wine – our measure of competition - on our measure of price dispersion. The magnitude varies across geographical markets (cities or neighbourhoods) but the results show a relatively consistent magnitude at around .2, increasing as one moves from neighbourhood to city level and varying slightly across cities. All are measured as elasticities so that the interpretation of the coefficients would be the percentage increase in price dispersion for a given percentage increase in the density. At the measured magnitude, the effect of competition is considerable at the city or neighbourhood level. An investigation of the reasons for this relation between density and competition follows in the next section.

We will investigate the data more thoroughly after we present the theoretical model, as this will suggest some further investigations of the data. Still, we include for interest the effects of various controls. The length of the wine list and the number of vintages per wine have a positive effect on dispersion; however, wines within category tend to have a negative effect on dispersion[45]. The percentage of variation explained is small, as in a number of other studies of price dispersion. Even though the percentage of dispersion explained may be small, the point is that we are more interested in why this dispersion might change with competition not necessarily in dispersion on its own.

We turn now to a model of price dispersion in wine sales as part of restaurant meals in the next section to help us understand these results.

4. A Model of Restaurant Competition with Wine Sales

With these characteristics of our market and the empirical results in hand, we now turn to a stylised model of wine sales in restaurants that captures some of these features in its broad strokes. We derive an equilibrium of this model that suggests that wine prices should exhibit more dispersion as the density of outlets increases in a geographic area.

a. Assumptions

[45]A longer wine list often is associated with a wine list award. It is likely because of this that the wine award does not come out as significant: the award itself is a bit redundant once the other wine list features are included. Our theoretical model is not set up to consider changes in the level of competition within restaurants, and indeed the way that the wine list is extended can have different effects on the price dispersion for any single wine so at this point there is no strong reason to expect any particular sign on this variable.

Restaurants are differentiated: two restaurants, A and B, are located at opposite ends of a Hotelling line. Unit "transportation" costs are equal to t. Each restaurant sells two kinds of goods, which are consumed together in a "meal". Each meal is a bundle consisting of food and a bottle of wine. There are two types of wine, 1 and 2. The Hotelling differentiation reflects differentiation between the restaurants due to distance, physical appearance or posted food menu, as is present in our data. As we will control for cuisine and appearance in our empirical work, the easiest interpretation of distance is indeed physical distance. This is also reflected in the empirical specification by our choice of the density of outlets offering the wine as the measure of competition.

The total mass of consumers along the line is 1. We have two types of consumers, however, "tourists" and "connoisseurs". Tourists have the same valuation V_T for either wine: they are unable to distinguish or do not care about the differences between wines. Connoisseurs, on the other hand, do perceive differences among wines: they have a valuation $V > V_T$ for the wine they like and a valuation of 0 for the wine they do not like. It is important that we assume that there is no "objectively" better wine that all connoisseurs would prefer: wine preferences are largely a matter of taste. Indeed, Cardebat and Livat (2016) and Chiccetti and Chiccetti (2013) provide support for this, showing that even wine expert ratings reflect taste for certain regions or other specific characteristics and that this taste element explains a good deal of the lack of consensus on the identity of a "good wine". All consumers purchase only a single wine to accompany their food.

Some of these consumers are short term actors in the market whereas others are long term actors. Connoisseurs live for two periods while tourists exit after one period and are replaced. As connoisseurs live for two periods, they can switch if they do not like the restaurant that they selected in the first period[46]. Travel to any outlet involves a transportation cost from the consumer's "home" location that must be factored into the price of consuming. One can think of connoisseurs as local consumers, who learn about restaurants and try to find a good match for their tastes so that they can return to the outlet in future, whereas tourists are visitors to the city who simply select a restaurant based on publicly available information (and perhaps a spirit of adventure) as part of their visit.

The amount of information prior to purchase differs across food and wine. The price of food at restaurant *i* is observable before purchase and is equal to P_{Fi}, with marginal cost c_F. The price of wine *j* at restaurant *i* is P_{ji} with marginal cost c_w. For wines, this cost is the opportunity cost of selling wine in the restaurant, proxied by the price that the bottle would fetch if sold at public auction and so equal across restaurants. The marginal cost of food is more straightforward as a price of preparation. We assume these costs are the same across

[46] We can add a search cost separate from the transportation cost, which complicates but does not change the main result. Details are available from the authors upon request.

the establishments in what follows and indeed to save on notation we largely suppress these terms in what follows as including them explicitly does not change the basic result.

The price of wine is only observed after the consumer has entered and "committed" to the restaurant in the sense of being obliged to purchase a meal. It should be clear from the start that restaurants have an incentive to charge the maximum possible price V_T for the bottle that is "targeted" at tourists and charge a higher price than that for the other bottle, targeting the share of connoisseurs who favour it[47]. This is assumed in what follows and simplifies the analysis. That such pricing is indeed part of the equilibrium is shown formally in the appendix[48]. We also assume that prices are chosen once and for all at the beginning of the first period[49]. The timing of the game and the information available to restaurants and consumers at each stage are as follows.

At time 0 both restaurants choose the bottle that they will target at tourists. When doing so, the choice of the other restaurant is not known. We assume that each restaurant randomises in this choice to capture a lack of coordination in the market[50]. Hence, we define $\gamma_i, i \in \{A, B\}$ as the probability that restaurant i targets bottle 2 to tourists, i.e. that $P_{1i} = V_T$. At time 1, each restaurant chooses the price of food, $P_{Fi}$and the price of the wine bottle that is targetted at connoisseurs. When choosing the price of the connoisseurs' wine a restaurant does not know the identity or price of the connoisseur wine at the other restaurant. This price decision will therefore be a function of the γs and of the restaurant (and consumers') expectation about how its rival prices the connoisseur wine.[51]

There are two types of consumers adding up to a mass of one. A proportion α of consumers is composed of tourists. Tourists consume one unit of food for each unit of wine. We assume that connoisseurs are equally split between those who like wine 1 and those who like wine 2. For each unit of wine connoisseurs consume μ units of food. Hence, where $\mu < 1$ then connoisseurs spend less on food than tourists. If $\mu > 1$, then we can think that connoisseurs

[47] We share this assumption with the add on literature. Lal and Matutes (1994) find that the monopoly price is charged for an add on to the "captive" segment. They do not consider the case of multiple add ons, though, as we do here, since they do not investigate dispersion within the add on price as we do.

[48] One additional parameter restriction needs to hold for this to hold, which is presented in the appendix. It is not terribly easy to interpret, however, so we do not dwell on it. Simulations also confirm the approach taken here.

[49] We note that, while ours is not a search model but instead a standard spatial model, this assumption is standard in search models where learning is present. Furthermore, our interest is in deriving an equilibrium in a model where prices are highly stable, as we observe in the data.

[50] This assumption eliminates the need to assume that restaurants would, for example coordinate to split the market (e.g. one restaurant choosing bottle 1 for tourists and the other bottle 2). We view this coordination as unlikely at the level of the cities we study since the number of restaurants is relatively high. A market that coordinates fully would display no dispersion in our model.

[51] The model is deliberately simplified compared to reality. With many restaurants to choose from, the problem of learning about restaurants in the vicinity is not as simple as this story of two restaurants and two wines on the winelist. Our approach captures a consumer accumulating knowledge of sommeliers' tastes across the market and their compatibility with the consumer's.

"splurge" on food compared to tourists[52]. At time 1, each type of consumer chooses which restaurant to patronise given the information that is available. Consumers observe food prices but only have an expectation of the price of the targeted connoisseur bottle at each restaurant.

At time 2, the beginning of the second period, a new generation of tourists enters the market while first-period tourists disappear. Connoisseurs must re-select where to eat. The only difference between their second period choice and the choice in period one is that they now know for the restaurant they experienced the identity of the tourist bottle and the price and identity of the connoisseur bottle. Importantly consumers still do not know the identity and price of the connoisseur bottle chosen by the restaurant they have yet to experience.

We solve for a symmetric fulfilled expectation equilibrium, i.e we solve for a symmetric Nash equilibrium given the parties' expectations about the variable that they have not observed. Then, we impose the condition that these expectations must be correct in equilibrium. We assume that the market is fully covered (there are no gaps where consumers do not purchase at restaurants). In other words, we are only concerned with modelling the restaurant-going public, not with the question of those who decide not to patronise the restaurants at all.

b. Consumer Behaviour

i Tourists

Tourists know all relevant information before choosing a restaurant since they can observe the price of meals and can easily infer that the tourist wine is sold at V_T. Accordingly, they behave like regular "Hotelling" consumers, buying from A if they are located to the left of a critical point x_T^* and buying from B if they are located to the right of x_T^*, where

$$x_T^* = \frac{1}{2} + \frac{P_{FB} - P_{FA}}{2t}$$

Where the price of wine simply cancels out of the expression since the optimal tourist price is the same at all outlets. Hence, the market divides in the middle, adjusted for any difference in the price of food across restaurants.

ii Connoisseurs

Let us look at a connoisseur located at *x* and who prefers wine 1. We call this a "type one" connoisseur. Assume that this connoisseur goes to A in the first period. There are two possible scenarios. In the first scenario, the consumer finds wine 1 priced for tourists. In that case, the consumer has no reason to switch to B in the second period because we know from our introductory comments about the model that no lower price for this wine will be found

[52]One can think that connoisseurs tend to order a full meal, with appetizer, dessert, coffee, and the main meal. This would roughly double the bill, giving a value of 2 for μ.

in the market. In the second scenario, the bottle of wine 1 is priced at $P_{1A} > V_T$. This means that the connoisseur might want to switch to B in the hope of finding wine 1 priced for tourists there. Such a switch is worthwhile if:

$$R + V - P_{FA} - tx - P_{1A} \leq R + V - P_{FB} - t(1 - x) - (1 - \gamma_B)V_T - (\gamma_B)E(P_{1B})$$

where R is the reservation price for food and V is the connoisseur's reservation price for her favourite wine.

This condition reflects the facts that the consumer knows that her favourite bottle is available at P_{1A} in restaurant B but only knows that it is available in restaurant B at a price V_T with probability $(1 - \gamma_B)$ and at an expected price $E(P_{1B})$ with probability (γ_B). This condition is equivalent to:

$$\leftrightarrow x \geq x^*_{C2A} = x^*_T + \frac{[(1 - \gamma_B)V_T + (\gamma_B)E(P_{1B}) - P_{1A}]}{2t}$$

As expected, as the expected price of the connoisseur bottle at restaurant B rises, more consumers move toward restaurant A. Note, however, that this cut-off depends on the *actual* price charged for wine 1 where it has been observed. Similarly, for a type one connoisseur who chooses B in the first period, we have:

$$R + V - P_{FB} - t(1 - x) - P_{1B} \leq R + V - P_{FA} - tx - (1 - \gamma_A)V_T - (\gamma_A)E(P_{1A})$$

$$\leftrightarrow x \leq x^*_{C2B} = x^*_T + \frac{P_{1B} - (\gamma_A)E(P_{1A}) - (1 - \gamma_A)V_T}{2t}$$

We can then describe the behaviour of our connoisseur who prefers bottle 1 in the first period. Define:

$$E(x^*_{C2A}) = x^*_T + \frac{[(1 - \gamma_B)V_T + (\gamma_B)E(P_{1B}) - E(P_{1A})]}{2t}$$

This incorporates the consumer's expectation of the second period cut-off for type one connoisseurs. As such it does not depend on the actual price of wine 1. Learning the locally observed wine price affects the market shares in the later consumption period for those consumers who are present in the market in both periods and care about the wine they drink.

All connoisseurs at a location closer to restaurant B than this marginal consumer decide to switch in period 2. In other words, the marginal consumer in period 1 is the consumer such that $x = E(x^*_{2CA})$.

Now, we consider the first period choice between consuming at A and B for a consumer who will wish to switch. We will assume a configuration and then will verify that this is an equilibrium. Assume, then, that there are consumers who would consider switching in the second period and solve the model under this assumption. Indeed, this assumption will end up satisfied trivially in the model: because the marginal consumers allocate themselves only according to expectations in the first period, there will normally be some switching that occurs in the second period once learning has occurred.

The expected utility of choosing restaurant A in period 1 for a marginal connoisseur of type 1 over the two periods, applying a "discount factor" of δ to the second period is:

$$E(U_{CA}) = (R+V)(1+\delta) - (1-\gamma_A)(1+\delta)[tx + P_{FA} + V_T]$$

$$- (\gamma_A)[tx + \delta t(1-x) + P_{FA} + \delta P_{FB} + E(P_{1A}) + \delta(1-\gamma_B)V_T$$

$$+ \delta(\gamma_B)E(P_{1B})]$$

In other words, the type 1 connoisseur who selects restaurant A in period 1 has a probability $(1-\gamma_A)$ of finding her preferred wine at the tourist price and so continuing to patronise this restaurant. She has a probability $(\gamma_A)$of discovering that it is priced higher. In this case, she may switch restaurants. If she does, then she expects to pay the tourist price with probability $(1-\gamma_B)$ and the higher price with probability (γ_B).

In what follows, note that we do not impose the usual restriction that $\delta \leq 1$. This is because, in our model one can think of the δ parameter as reflecting both the usual discount rate and the relative "length" of the two periods. In this sense $\delta > 1$ can be reasonable if connoisseurs keep coming back frequently once the uncertainty about wine prices has been lifted through experience. A better wording for this term is, then, a "weighting factor" between the present and a customer who remains with the restaurant "for life".

The expected utility from choosing B in period 1 for a marginal connoisseur of type 1 who would switch to restaurant A if she finds upon sitting down at restaurant B that her preferred bottle receives the higher price is analogously stated as:

$$E(U_{CB}) = (R+V)(1+\delta) - (1-\gamma_B)(1+\delta)[t(1-x) + P_{FB} + V_T] - (\gamma_B)[t(1-x) +$$

$$\delta tx + P_{FB} + \delta P_{FA} + E(P_{1B}) + \delta(1-\gamma_A)V_T + \delta(\gamma_A)E(P_{1A})]$$

So that the connoisseur chooses A if the following condition holds:

$$tx([-(1+\delta)[(1-\gamma_A) + (1-\gamma_B)] - (2-(1-\gamma_A) - (1-\gamma_B))$$

$$+ \delta(2-(1-\gamma_A) - (1-\gamma_B))] - P_{FA}[(1+\delta)(1-\gamma_A) + (\gamma_A) - \delta(\gamma_B)]$$

$$+ P_{FB}[(1+\delta)(1-\gamma_B) + (\gamma_B) - \delta(\gamma_A)] - E(P_{1A})[(\gamma_A) - \delta(\gamma_A)(\gamma_B)]$$

$$+ E(P_{1B})[(\gamma_B) - \delta(\gamma_B)(\gamma_A)]$$

$$- V_T[(1-\gamma_A)(1+\delta) + (\gamma_A)\delta(1-\gamma_B) - (1-\gamma_B)(1+\delta) - (\gamma_B)\delta(1$$

$$- \gamma_A)] - t[(\gamma_A)\delta - (1+\delta)(1-\gamma_B) - (\gamma_B)] \geq 0$$

$$\leftrightarrow tx[2(\delta-1) - 2\delta(1-\gamma_A + 1-\gamma_B)] + (P_{FB} - P_{FA})[\delta(1-\gamma_A + 1-\gamma_B) + (1-\delta)]$$

$$+ (\gamma_B)E(P_{1B})\big(1-\delta(\gamma_A)\big) - (\gamma_A)E(P_{1A})(1-\delta(\gamma_B)) - V_T(1-\gamma_A$$

$$- (1-\gamma_B)) - t[(\delta-1) - \delta(1-\gamma_A + 1-\gamma_B)] \geq 0$$

$$\leftrightarrow x \leq x_T + \frac{(\gamma_B)E(P_{1B})\big(1-\delta(\gamma_A)\big) - (\gamma_A)E(P_{1A})(1-\delta(\gamma_B)) - V_T(1-\gamma_A - 1+\gamma_B)}{2t[(1-\delta) + \delta(1-\gamma_A + 1-\gamma_B)]}$$

$$\equiv x_2^*$$

In other words, x_2^* is the "location" of the marginal consumer in period 1. It has the form of the market dividing point of the tourist market plus an "adjustment factor" that takes account of the expected price differences across wines.

Following our initial assumption that there would be switching from A to B in the second period, we must have

$$E(x_{2CA}^*) \leq x_2^*$$

This implies that there is a mass of consumers who in expectation will switch in equilibrium. An analogous condition for choosing B implies that there is a marginal consumer who falls in the switching range from restaurant B to A. In other words, to the left of x_2^* there is a range of consumers who may switch between x_2^* and $E(x_{C2A}^*)$, and an analogous group to the right of x_2^* extending until $E(x_{C2B}^*)$.

c. Profit Maximisation

Assume that restaurant A targets bottle 2 at tourists. We then maximise the following profit function[53]:

$$\begin{aligned} Max_{P_{FA},P_{1A}}[P_{FA} - c_F][(1+\delta)\alpha x_T + \frac{1-\alpha}{2}\mu\big(x_2^*(1+\delta)\big) + \frac{1-\alpha}{2}\mu(x_2^* + \delta x_{2CA}^* + \delta(x_{2CB}^* \\ - x_2^*)] + (V_T \\ - c_w)[(1+\delta)(\alpha x_T + 0.5(1-\alpha)x_2^*) + 0.5(1-\alpha)\delta(1-\gamma)(x_{2CB}^* - x_2^*)] \\ + (P_{1A} - c_w)[0.5(1-\alpha)(x_2^* + \delta x_{2CA}^* + \delta\gamma(x_{2CB}^* - x_2^*)] \end{aligned}$$

In other words, profits are composed of a price margin for food multiplied by the tourists who visit A in the two periods, plus the connoisseurs of either type who select and remain at A, those who move to B after trying A and those who switch to A in later periods. Profits also include the margin on the tourist wine for all tourists but also those connoisseurs lucky enough to have found their preferred wine at the tourist price either initially or when they switched to the restaurant in period 2. It also includes the margin on the wine that the restauranteur has selected to target to connoisseurs and is purchased by connoisseurs who either selected and remained at A or those who switched to A in search of their preferred wine at the tourist price. Indeed, this last group ends up disappointed.

For simplicity of notation, we now take all prices as net of costs. We derive the first order condition taken with respect to food price:

[53] We include the costs of food and wine here to illustrate where they enter, but the rest of the section suppresses these terms for brevity.

$$\leftrightarrow \frac{\partial \pi}{\partial P_{FA}} = [(1+\delta)\alpha x_T + \tfrac{1-\alpha}{2}\mu\big(x_2^*(1+\delta)\big) + \tfrac{1-\alpha}{2}\mu(x_2^* + \delta x_{2CA}^* + \delta(x_{2CB}^* - x_2^*))] -$$

$$\tfrac{P_{FA}}{2t}(1+\delta)\big(\alpha + \mu(1-\alpha)\big) - \tfrac{V_T}{2t}(1+\delta)\left(\alpha + \tfrac{1-\alpha}{2}\right) - \tfrac{P_{1A}}{2t}(1+\delta)\tfrac{1-\alpha}{2} = 0$$

The first term represents the direct effect of the price change on food sales, while the later terms all reflect the indirect effect of the food price on the location of the marginal consumer.

Imposing fulfilled expectations (ie, consumer expectations on all prices are correct) and symmetry (ie, prices are the same across restaurants, the gammas are the same across restaurants, and untargeted connoisseur wines are selected to be the same across restaurants) we see that:

$$x_T = x_2^* = \frac{1}{2}$$

$$x_{2CB}^* = \frac{1}{2} + \frac{(1-\gamma)(P_1 - V_T)}{2t}$$

$$x_{2CA}^* = \frac{1}{2} + \frac{(1-\gamma)(V_T - P_1)}{2t}$$

$$\rightarrow \frac{\partial \pi}{\partial P_{FA}} = \frac{1+\delta}{2}(\alpha + \mu(1-\alpha)) - \frac{2P_F}{4t}(1+\delta)(\alpha + \mu(1-\alpha))) - \frac{V_T}{4t}(1+\delta)(\alpha+1)$$

$$-\frac{P_1}{4t}(1+\delta)(1-\alpha) = 0$$

$$\leftrightarrow 2t(\alpha + \mu(1-\alpha)) - V_T(1+\alpha) = 2(\alpha + \mu(1-\alpha))P_F + (1-\alpha)P_1$$

We also have

$$\frac{\partial \pi}{\partial P_{1A}} = [0.5(1-\alpha)(x_2^* + \delta x_{2CA}^* + \delta\gamma(x_{2CB}^* - x_2^*)] - \frac{P_F}{2t}\mu\delta\frac{1-\alpha}{2} - \frac{P_1}{2t}(\delta)\frac{1-\alpha}{2} = 0$$

Imposing symmetry we get[54]

$$\frac{\partial \pi}{\partial P_{1A}} = \frac{1-\alpha}{4}\left[(1+\delta) + \delta(1-\gamma)\frac{V_T - P_1}{t} + \delta(1-\gamma)(\gamma\frac{P_1 - V_T)}{t})\right] - \frac{P_F}{2t}\mu\delta\frac{1-\alpha}{2}$$

$$-\frac{P_1}{2t}(\delta)\frac{1-\alpha}{2} = 0$$

$$\leftrightarrow (1+\delta)t + \delta(1-\gamma)(1-\gamma)V_T \ = \mu\delta P_F + \delta(1+(1-\gamma)(1-\gamma))P_1$$

Solving these two FOCs we get[55]

P_1^*

$$= \frac{2t[\alpha+\mu(1-\alpha)][1+\delta(1-\mu)] + \delta V_T[[(1-\gamma)(1-\gamma)][2(\alpha+\mu(1-\alpha)] + \mu(1+\alpha)]}{\Delta}$$

Where

$$\Delta = \delta[2\alpha\,[1+(1-\gamma)(1-\gamma)] + \mu(1-\alpha) + 2\mu(1-\alpha)(1-\gamma)(1-\gamma)]$$

The denominator will always be positive[56].

[54] Second order conditions hold but are omitted. Details available from authors.

[55] If the additional switching cost is positive, then for switching cost s, this expression contains an additional term in the numerator of 2AB, where $A = \alpha + \mu(1-\alpha)$ and $B = s\delta(1-\gamma)$. This affects the level of P_1. If the switching cost is in the range such that the current description of behaviour continues to hold, then the expression for the derivative does not change. Clearly, though, switching costs can be so high that no switching occurs.

[56] We also need price to remain positive, but for the condition that we apply to obtain price dispersion, below, price does remain positive.

Hence

$$\frac{dP_1^*}{dt} = \frac{2[\alpha + \mu(1-\alpha)][1 + \delta(1-\mu)]}{\Delta}$$

As the denominator is positive we see that the price of the wine aimed at connoisseurs decreases or increases as competition intensifies (i.e. t decreases) depending on the sign of $[1 + \delta(1-\mu)]$. Greater competition leads to higher wine prices (and hence, more dispersion across restaurants as these choose the targeted bottle randomly) if

$$1 + \delta(1-\mu) < 0$$

This requires that $\mu > 1$, i.e. that connoisseurs spend more on food than tourists. One way to think about this is that the connoisseurs tend to purchase a full meal with appetiser, dessert, and coffee whereas the tourists tend to purchase the main meal only. The weighting factor of the two periods must lie above a lower bound. This seems reasonable to assume, if only based on what is known of wine pricing in restaurants. While we do not restrict δ to be less than one, following our interpretation of this as a "weighting" rather than a pure discount factor, we note that in any event, price dispersion can increase with competition for values of δ below 1 where μ falls within a corresponding range.

d. Intuition and Modifications

The intuition for this result differs from some other models where competition increases price dispersion, so we present it in some detail here. The effects of competition on the price of wine go through two routes. First, there is a direct effect of competition on the price of wine. Second, competition affects the price of food and the prices of food and wine interact as part of the optimal policy.

The restaurant would like to minimise the number of potential repeat customers who go elsewhere to eat in the second period. Lowering the price of wine can promote this. The greater is t (the differentiation in the market, or the distance), the lower is the "pull" of the competing restaurant, so the less pressure there is on the price of wine. Hence, wine price will tend to rise with a decrease in density. This effect suggests that the price of wine falls as competition rises, in accordance with standard Hotelling competition, even though these prices are not observed before the initial choice of restaurant. Lowering the price of wine does not improve custom in the first period because customers do not observe the wine price until they have entered the restaurant and purchased a meal. Wine is an "add on" in this sense.

Food price is a way to attract customers in both periods, however, as the food price is posted. Clearly, competition increases pressure on the price of food as well. At the same time, there is an indirect effect on the price of wine running through the margin on food. When the price of wine falls, it acts to retain customers who seek a good price on their preferred wine. These customers also purchase food with the wine as part of the bundled meal. Hence, if the profit margin on food increases with *t*, this puts downward pressure on the wine price because the "prize" that is obtained in exchange for the lower wine margin increases. Similarly, if competitive pressure rises so that food margins fall, the price of wine will tend to rise since the value of obtaining a repeat customer via an attractive wine offer falls. It is this intuition that distinguishes our paper from the recent literature on price dispersion where bundles are purchased but individual components do not interact as they do here (eg, Kaplan et al, 2019) and follows from our distinctive modelling assumptions, based on our market of interest.

This intuition should not be interpreted as saying that customers have no preference over food. They very much do, as we can see from the Hotelling line, which can be taken to represent differentiation in the offering of the restaurants (perhaps including considerations of cuisine, as reflected in our econometric treatment controlling for this). The difference is that the position on the line and the price of food are directly observed *ex ante*, whereas the price of wine is not. As a result, customers must seek their preferred wine, and are more likely to do so if their preferred bottle is priced higher at their initial restaurant selection. In this sense, it is search that drives the dispersion result on wine but not on food. At the same time, the interaction between food and wine price is crucial to obtain the effect that we do since food price changes the incentive of the seller to exercise this pricing.

In order to have this generate price dispersion in (each) wine, it is important that the wine be both an add on and that the tourists be short term consumers: if connoisseurs know the price and identity of tourist bottles, then they will adjust their selected restaurant accordingly and if tourists repeat their custom then pricing will change so as to affect their repeat purchase behaviour. With the tourist bottle price "fixed" at V_T, second degree price discrimination implemented in a particular way creates the price dispersion in this market. As competition rises, the restaurants would normally decrease price to retain higher margin customers. While this price decrease could normally affect both food and wine prices, in our framework it makes no sense to adjust the tourist bottle price down. As a result, food price adjusts more than it would if all prices could usefully be adjusted. For the connoisseur bottle, it does make sense to adjust the bottle price somewhat, of course, but the additional reduction in the food price for both tourist and connoisseur groups will result in a more modest downward adjustment in the price of the connoisseur bottle or, if the effect is strong enough, even move the connoisseur price upwards.

We might expect the effect of wine consumption to be relatively small since all customers purchase food but only some are the repeat customers who drive the switching effect. At the same time, when μ is large, then the effect of the repeat customers gets larger as well since

they are the "big spenders" on food. Hence, the means of attracting the connoisseurs becomes a larger driver in pricing policy. The magnitude of this effect, at least with our simple modelling, is within a realm reasonable enough that one should expect the effect to show up in the data. If connoisseurs also are customers who tend to purchase appetizers, cocktails, desserts, coffee, and other extras the bill can easily double compared to consumers who might only purchase an entrée. In our simple model, this means that any weighting on the repeat custom exceeding ½ would satisfy the increasing dispersion criterion. Given the importance of repeat custom in the trade press, this appears not unreasonable.

As the weight of the future period is larger, we also see an increased importance of repeat custom in the total profit of the restaurants so that either an increase in δ or an increase in μ has a similar effect. Hence, even if δ is large so that the future weighs heavily in the decision problem, if connoisseurs are not valuable to retain (μ is sufficiently small) then the standard competitive effect will dominate. Similarly, even if connoisseurs are "big spenders", if the restaurant does not care about future periods then there is no reason for anything but the standard competitive mechanism to be in place. The result, even for the equilibrium we have derived, has enough ambiguity that it is an empirical question which effect will dominate. In the event, the empirical results suggest that the effect of repeat custom and "big spenders" appears to be large.

We note that our model depends on the assumption that the same wine may play a different role in different wine menus: sometimes priced to attract one type of consumer and sometimes being directed at another type. This might be more accurate for some categories of wine than for others. Hence, one might expect that price dispersion would not increase for some segments of wine, such as "iconic" wines, whereas it might for other, more ordinary, wines. We turn to this possibility in the following section as a way to check that our model might be explaining what we see in the data.

We make many specific assumptions in this simple model, which can be relaxed with little substantive effect on the result and its intuition. Including a proportion of the public who do not drink can be accommodated, for example, and is clearly a realistic extension. As it does not affect the nature of the results, we leave it aside. Second, in our simple framework of two wines, two restaurants, and two periods, it conceivable that consumers could "figure out everything beforehand". Endowing our consumers with this ability would defeat the purpose of the modelling: we wish to present a framework that is as simple as possible and gets across a point so that we can discern the mechanism. Our view of real restaurant markets is that information is significantly incomplete due to fluctuations in the offering and the sheer variety of wines (and food) available, let alone effects of changing in staff and management. As a result, we introduce an exogenous source of randomisation that is unmodelled (the initial choice of wine to target at connoisseurs) and take this to capture many of the uncertainties that characterise a true restaurant experience. More in depth work could address this exogeneity, but complete modelling of the complexities of restaurant meals is not our

endeavour here. Finally, modifying the functional form of the transportation cost does not make much difference to the results: the functional form changes, but the message does not. Indeed, modifying the empirical specification to include various types of transportation cost or non-linearities does not generate any significant changes in the results so we have not pursued modified assumptions on transportation here[57].

Summarising the results of this section, we have proposed a theoretical model that is consistent with both the features of the market for wines consumed in restaurants and the empirical results that we obtain. It is not the only model we could propose, but we find that the "off the shelf" models do not fit our market's institutions nor our data's behaviour very well. As such, we propose that our theory, while not formally tested by the empirical work, is a reasonable intuition for why price dispersion might be observed in wines.

5 Empirical Discussion

Our theoretical specification is consistent with the direction of the effect of competition on dispersion in our empirical results, but the results we have derived do not constitute in themselves a test of the theory model compared to other possible explanations. Indeed, restaurant pricing may be traced to many types of behaviour and so our model can only be one, not the only, explanation for the pricing we observe.

Some of the theories of price dispersion do not square with the assumptions that underlie our market. Further, we can take some cues from our data and regressions on whether our model, and others, are compatible with the results.

Other papers have suggested that price dispersion results from a mixed strategy equilibrium with rank reversals in prices over time as evidence of this. Lewis (2008) is an example of this view and finds that price dispersion generally increases with competition, as we do. However, we do not detect the type of rank reversals over time in wine prices. Indeed, as mentioned above, almost three quarters of prices simply do not change at all. Indeed, empirically, this means that we need to treat our panel as a cross section, since there is not enough variation to treat it as a true panel. Similarly, our prices do not "fall away" as one might expect in a stock out model or a model with occasional sales. Instead, we share with Kaplan et al (2019) the observation that prices are unusually stable across outlets and over time. As such, there is no *prima facie* case for alternative models based on the institutions and data features of our market.

[57] Chandra and Tappata (2011) note that in standard search models, one would expect price dispersion to be positively related to competition but at a decreasing rate. Indeed, the shape of our relation depends on the shape of the transportation cost, so we have no reason to predict a single "shape" as our functional forms are not necessarily so well defined. In the event, the log-log specification seems to fit the data well: our experiments with other functional forms have not generated significant coefficients on the other non-linear terms.

The theory suggests that the high prices rise with competition, increasing the average price of wine as well as price dispersion. The average price also rises with competition, meaning that a "residual price" (the deviation compared to the average) would exhibit increasing spread compared to the mean: the average rises less than the top of the distribution and the average also rises with respect to V_T, the bottom of the distribution. This contrasts our results with those of Syverson (2007), where competition drives out inefficient firms, causing average price to fall (and dispersion with it). Syverson's approach is compatible with relatively stable prices, as we have.

Aside from being compatible with price stability, our framework also suggests that price dispersion occurs because the same wine is being used for different purposes at different outlets. In some sense, the dispersion does not come from the product itself but from differences in its use within a menu offered to customers. This means that if we were to divide up the sample into wines that likely occupy the same place on the menu across outlets, such wines should not exhibit the same pattern. For example, if wine 1 in our model were always directed at connoisseurs and wine 2 were always directed at tourists, we would see no dispersion in our theoretical results at all.

We do, in fact, have some wines that likely always play the same role in the menu: those of high quality "cru" classes. We would expect that such "iconic" wines would always be targeted at the same consumer group. If this is the case, and focussing on our interest in how dispersion varies with competition, we should expect no relation between dispersion and competition in the "iconic" group , whereas we should still observe this result holding in the "ordinary" group of wines.

We can illustrate the relation of prices and competition as well as the dispersion of the stripped price for different wine categories. The maximum raw prices tend to rise much faster than the minimum raw prices as competition increases, generating the results in Figure 2a, below, for both "all" and "ordinary" wines, although less so for "iconic" wines. On the other hand, the stripped prices exhibit increasing dispersion around the average as competition rises for "all" and "ordinary wines", but no relation for "iconic" wines, shown in Figure 2b. In other words, the stripped prices are consistent with a top raw price rising, the average price rising (less) and a relatively stable bottom raw price. The iconic category seems less consistent with our framework, as we might expect if there is little heterogeneity in the targeting of such bottles.

Figures 2a and 2b here

We divide the sample and re-run our second stage equations on iconic and ordinary groups, with results illustrated in Table 7. These results confirm that the iconic group does not,

indeed, reflect dispersion that increases with competition (or varies with competition at all). The ordinary group continues to reflect the pattern of the general data that we illustrated in Table 6.

Table 7 here

The inference about differences in price dispersion across these "quality groups" in wines from ordinary to iconic comes from our inference that quality is associated with homogeneity in the relevant consumers. Even if customer groups differ, as in our model, we have found in the theory that if the differences are not significant enough (in our framework, this amounts to connoisseurs not only having different preferences over wine, but also spending) the relation between dispersion and competition would not be increasing. Even if customer groups differ the ways we have specified, the proportions can change so that one group predominates. This mix of consumers is reflected in the model by the parameter α. If one examines cross derivatives of the price of the connoisseur wine in the model as one makes the customer group more homogeneous (ie, a change in α), then one does not come out with a firm prediction on the sign, in general. Even setting this aside, changing α on its own assumes that as the customer population changes the selection of restaurants does not, which may not be realistic. If one were to assume to the contrary that there is a change – say an increase in consumer groups, then the effect on the theoretical result would depend on how the number of most preferred wines increases with consumer groups: the results from increasing from two preferred wines in two restaurants and with two consumer groups to N preferred wines, N restaurants, and N groups may not make much difference whereas increasing asymmetrically across these different groups may well create new effects. We have no indication of how the simple model scales up to the data on this dimension, however, so we leave this as unsettled.

Taking these remarks to the data, we have relatively good quality measures. Other work on dispersion has generated inconclusive effects of quality on the relation between dispersion and competition. Dubois and Perrone (2015) suggested in their study of price dispersion in supermarkets that infrequently-consumed and more expensive items do not necessarily perform empirically in the same way as cheaper and frequently purchased items (eg, fine whiskey compared to a bottle of milk). Kaplan et al (2019) do not find significant differences across quality groupings in dispersion. Lewis (2008) finds potential differences in dispersion depending on the quality of the outlet, but quality is admittedly harder to measure for his market.

Returning to Table 6, we did not find a significant difference based on our quality ratings of Michelin stars or Wine Spectator awards. If one accepts the hypothesis that we did find a difference when dividing up wines into the "iconic" and "ordinary" categories because of more homogeneity in the "high quality" category of wines, then one suggestion for why quality measures like Michelin stars do not affect price dispersion behaviour is that these quality measures do not sort consumers into a more homogeneous group. If quality need not

be associated with homogeneity, then there is no reason to expect that it should be associated with different price dispersion behaviour.

We assume that the value of the preferred wine for the connoisseur is the same across restaurants, so that there is no additional value in the sommelier's match of wine to meal that might induce differences across restaurants. Our model could be interpreted as implicitly assuming that the restaurants all do an equally good job matching the wine to the meal. We capture this very simply in the empirical work with a restaurant fixed effect that should allow us to correct for heterogeneous sommelier ability across establishments without making this a focus of the work[58].

Gerardi and Shapiro (2010) point out that for their case of price discrimination in airline routes, competition tends to decrease dispersion, as one would expect if dispersion is due to price discrimination. Our results are not directly comparable to theirs, as a "route" in their model is like a "restaurant" in our model. As such, our examination would be across routes whereas their examination would be associated with looking at the wine list within restaurants. Their paper allows for different prices targeting different consumer groups, whereas ours does not. To the extent that competition across restaurants is closer to the sort of competition studied in gasoline markets (like Lewis, 2009, and Pennerstorfer, 2020), and to the extent that third degree price discrimination (and discrimination across time) is not possible in our framework, our approach is closer in spirit to the latter experiments.

Summarising our results of this section, we find that the assumptions of some alternative models do not fit our data well in the sense that our prices are far more stable than is required in some other approaches. For other models with stable prices, we find that our pattern of increasing dispersion with competition does not match with Syverson (2007), and our institutional framework does not fit with the model of Kaplan et al (2019). We find that where quality is associated with likely more homogeneous customer groups the positive relation between competition and price dispersion falls away, but where quality is not necessarily related to homogeneity there is no significant change from our baseline results. Overall, the examination of alternative models in this section does not result in a compelling alternative candidate for our market and data features.

6. Conclusions

We have studied price dispersion in wine sales in restaurants in both an empirical and a theoretical model. We start by using a rich dataset of Bordeaux wines collected in three waves and for five cities to find a robust positive relationship between price dispersion and density of outlets at the city and more local level.

We develop an intuition for why this might be the case that is adapted to our industry of interest but also holds some interest more generally as a case where dispersion could result

[58] See, however, Choi et al (2018) for modelling of match quality albeit in a different context.

from the interplay of goods purchased in a bundle. Our model suggests that wine prices should exhibit price dispersion that increases with competition where those who care about the wine they drink also tend to be larger spenders on meals generally and/or there is high importance on repeat purchase in this market. The intuition is that increased competition in the "base" product as density of outlets increases reduces the pressure on wine price as a way to "entice" customers to the restaurant to consume the full meal. This means that wine price may rise for some segments of consumers that are attracted by the wine menu. The theoretical model itself adds to a large set of models of price dispersion and to a smaller set of models of add ons. The intuition of the price dispersion on wines working indirectly through the price effect on food of a change in competition is novel, however.

Empirically, we add to the literature on restaurant pricing at local and less local levels and by extending work beyond fast food. Indeed, restaurant consumption is becoming increasingly important as a portion of household budgets so turning attention to this sector is interesting in itself. We also measure "quality" in various ways, suggesting that where quality groupings make relevant consumer groups more homogeneous then they should affect the relation between price dispersion and competition. Quality labels that do not sort customers in this way should not. This may explain the divergent results on quality in the existing empirical literature on price dispersion.

Other explanations may exist for the observed dispersion in this market. Our work does not rule this out. At the same time, our model may be of interest to those studying markets with complex goods. Indeed, several of the single good models of price dispersion are in a context where add ons are present (such as convenience store items alongside gasoline purchase) even if they not modelled.

References

Almenberg, J., & Dreber, A. (2011) “When does the price affect the taste? Results from a wine experiment”, Journal of Wine Economics 6(1), 111-121.

Anderson, S., & Renault, R. (2000). “Consumer Information and Firm Pricing: Negative Externalities from Improved Information”, International Economic Review 41, 721-742.

Arbatskaya, Maria, (2007) “Ordered Search”, Rand Journal of Economics 38(1), Spring. 119-126.

Armstrong, Mark, (2017) “Ordered Consumer Search”, Journal of the European Economic Association 15(5) 989-1024.

--- and Yongmin Chen, (2009) “Inattentive consumers and product quality”, Journal of the European Economic Association 7(2/3), 411-422.

Ashenfelter, Orley, and Jones, Gregory (2013) “The Demand for Expert Opinion: Bordeaux Wine”, Journal of Wine Economics 8(3), 285-293.

Ashton, Robert H (2013) “Is There Consensus Among Wine Quality Ratings of Prominent Critics? An Empirical Analysis of Red Bordeaux, 2004-2010”, Journal of Wine Economics 8(20), 225-234.

Atkin, T., Nowak, L., & Garcia, R. (2007). Women wine consumers: information search and retailing implications. International Journal of Wine Business Research, 19(4), 327-339.

Barber, N., & Almanza, B. A. (2007). Influence of wine packaging on consumers' decision to purchase. Journal of foodservice business research, 9(4), 83-98.

Baughman, Garth, and Burdett, Kenneth (2016) “Multi-product Search Equilibria” http://www.cvstarrnyu.org/wp-content/uploads/106/10/baughman_burdett.pdf

Baye, Morgan and Scholten (2004), “Price Dispersion in the Small and in the Large: Evidence from an Internet Comparison Site”, Journal of Industrial Economics 52(4) 463-496.

Benfratello, Luigi, Piacenza, Massimiliano, and Sacchetto, Stefano (2009) “Taste or Reputation: What Drives Market Prices in the Wine Industry? Estimation of a hedonic Model for Italian Premium Wines” Applied Economics 41, 2197-2209.

Berenguer, G., Gil, I., & Ruiz, M. E. (2009). Do upscale restaurant owners use wine lists as a differentiation strategy?. International Journal of Hospitality Management, 28(1), 86-95.

Bodington, Jeffrey (2012) “804 Tastes: Evidence on Preferences, Randomness, and Value from Double-Blind Wine Tastings”, Journal of Wine Economics 7(2), 181-191.

Borenstein, Severin, and Rose, Nancy (1994) “Competition and Price Dispersion in the U.S. Airline Industry”, Journal of Political Economy 102(4), 653-683.

Brochet, F., & Morrot, G. (1999). Influence du contexte sur la perception du vin, implications cognitives et méthodologiques. Journal International des Sciences de la Vigne et du Vin, 33(4), 187-192.

Brown, G., & Getz, D. (2005). Linking wine preferences to the choice of wine tourism destinations. Journal of Travel Research, 43(3), 266-276.

Burdett, Kenneth, and Judd, Kenneth (1983) “Equilibrium Price Dispersion” Econometrica 51(4), 955-969.

Butters, Gerard (1977) “Equilibrium Distributions of Sales and Advertising Prices”, Review of Economic studies 44(3), 465-491.

Camera, Gabriele, and Cernii Selcuk, (2009) “Price Dispersion with Directed Search”, JEEA 7(6), December. 1193-1224.

Cao, J. (2014). Quantifying randomness versus consensus in wine quality ratings. Journal of Wine Economics, 9(2), 202-213.

Cardebat, Jean-Marie, F. Livat (2016) “Wine Experts’ Rating: A Matter of Taste?” International Journal of Wine Business Research, 28(1), 43-58.

Cardebat, J. M., & Paroissien, E. (2015). Standardizing expert wine scores: An application for Bordeaux en primeur. Journal of Wine Economics, 10(3), 329-348.

Cardebat, J. M., Figuet, J. M., & Paroissien, E. (2014). Expert opinion and Bordeaux wine prices: An attempt to correct biases in subjective judgments. Journal of Wine Economics, 9(3), 282-303.

Cason, Timothy and C. Nooussair (2007) “A Market with Frictions in the Matching Process: An Experimental Study”, International Economic Review, 48(2), 665-691.

Chandra, Ambarish, and Mariano Tappata, (2011) “Consumer search and dynamic price dispersion: An application to gasoline markets”, Rand Journal of Economics, 42(4), 681-704.

Chaney, I. M. (2000) “External search effort for wine”, International Journal of Wine Marketing, 12(2), 5-21.

Choi, M., Dai, A., Kim, K. (2018, “Consumer Search and Price Competition”, Econometrica 86(4), 1257-1281.

Cicchetti, Domenic, and Cicchetti, Arnie (2013) “As Wine Experts Disagree, Consumers’ Taste Buds Flourish: How Two Experts Rate the 2004 Bordeaux Vintage”, Journal of Wine Research 2494), 311-317.

Combris, Pierre, Lecocq, Sebastien, and Visser, Michael (1997) “Estimation of a Hedonic Price Equation for Bordeaux Wine: Does Quality Matter?” The Economic Journal 107 (March), 390-402.

Croce, Erica, & Perri, Giovanni (2017). Food and wine tourism: Integrating Food, Travel and Terroir. 2nd Edition. Cabi.

Dai, Mian, Q. Lui, and K. Serfes, (2014) “Is the Effect of Competition on Price Dispersion Nonmonotonic? Evidence from the US Airline Industry”, The Review of Economics and Statistics, 96(1), March. 161-170.

De Silva, Dakshina, Elliot, Caroline, and Simmons, Rob (2013) “Restaurant Wars: Spatial Competition in UK Restaurants” Lancaster University Management School Economics Working Paper Series 2013/013.

Dodd, T. H., Laverie, D. A., Wilcox, J. F., & Duhan, D. F. (2005). Differential effects of experience, subjective knowledge, and objective knowledge on sources of information used in consumer wine purchasing. Journal of Hospitality & Tourism Research, 29(1), 3-19.

Dubois, Pierre and H. Perrone, (2015) “Price Dispersion and Informational Frictions: Evidence from Supermarket Purchases”, Centre for Economic Policy Research Disucssion Paper 10906. October.

Ellison, Glenn (2005), “ A Model of Add-on Pricing”, The Quarterly Journal of Economics, May. 585-637.

Gaggero, Alberto, and Claudio Piga (2011), “Airline Market Power and Intertemporal Price Dispersion”, Journal of Industrial Economics, LIX(4). December. 552-557.

Gerardi, Kristopher, A. Shapiro (2009) “Does Competition Reduce Price Dispersion? New Evidence from the Airline Industry”, Journal of Political Economy 117(1). February. 1-37.

Gergaud, Olivier, Storchmann, Karl, and Verardi, Vincenzo (2015) “Expert Opinion and Product Quality: Evidence from New York City Restaurants”, Economic Inquiry 53(2), 812-835.

Giulietti, Monica, J. Otero and M. Waterson, (2010) “Pricing Behaviour Under Comptition in the UK Electricity Supply Industry”, Oxford Economic Papers, New Series, 62(3). July. 478-503.

Goldberg, Penny K and F. Verboven (2004) “Cross-Country Price Dispersion in the Euro Era: A Case Study of the European Car Market”, Economic Policy 19(40), 484-521.

Goldstein, R., Almenberg, J., Dreber, A., Emerson, J. W., Herschkowitsch, A., & Katz, J. (2008). Do more expensive wines taste better? Evidence from a large sample of blind tastings. Journal of Wine Economics, 3(1), 1-9.

Gomez-Lobo, Andres, (2007) “Why Competition Does Not Work in Urban Bus Markets: Some New Wheels for Some Old Ideas”, Journal of Transport Economics and Policy, 41(2), May. 283-308

Gupta, Sunil, and Zeithaml, Valerie (2006), “Customer Metrics and their Impact on Financial Performance”, Marketing Science 25(6), 718-739.

Harvey, Andrew (1976) “Estimating Regression Models with Multiplicative Heteroscedasticity”, Econometrica 44(3), 461-465.

Hastings, Justine (2004), “Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California”, American Economic Review 94(1), 317-328.

Hodgson, R. T. (2008). An examination of judge reliability at a major US wine competition. Journal of Wine Economics, 3(2), 105-113.

Imbs, Jean, H. Mumtaz, M. Ravn, H. Rey, (2010) “One TV, One Price ?” The Scandinavian Journal of Economics, 112(4), December. 753-781.

Jaeger, David, and Storchmann, Karl (2011) “Wine Retail Price Dispersion in the United States: Searching for Expensive Wines?”, American Economic Review 101(3), 136-141.

Jaeger, S. R., Danaher, P. J., & Brodie, R. J. (2010). Consumption decisions made in restaurants: The case of wine selection. Food Quality and Preference, 21(4), 439-442.

Kaplan, Greg, Menzio, Guido, Rudanko, Leena, Trachter, Nicholas (2019) “Relative Price Dispersion: Evidence and Theory”, American Economic Journal: Microeconomics 11(3), 68-124.

Kotonya, N., De Cristofaro, P., & De Cristofaro, E. (2018). Of Wines and Reviews: Measuring and Modeling the Vivino Wine Social Network. arXiv preprint arXiv:1804.10982. Cornel University.

Lacey, S., Bruwer, J., & Li, E. (2009). The role of perceived risk in wine purchase decisions in restaurants. International Journal of Wine Business Research, 21(2), 99-117.

Lach, Saul (2002), “Existence and Persistence of Price Dispersion: An Empirical Analysis”, Review of Economics and Statistics 84(3), 433-444.

Lafontaine, Francine (1995), “Pricing Decisions in Franchised Chains: A Look at the Restaurant and Fast-Food Industry” NBER Working Paper 5247. September.

Lal, Rajiv, and Matutes, Carmine (1989) “Price Competition in Multimarket Duopolies”, Rand Journal of Economics 20, 516-537.

Lal, Rajiv and Matutes, Carmine (1994) “Retail Pricing and Advertising Strategies” Journal of Business 67(3), 345-370.

Lewis, Matthew, (2008) “Price Dispersion and Competition with Differentiated Sellers”, Journal of Industrial Economics LVI(3), September, 654-678.

Livat, Florine and H. Remaud (2018) “Factors impacting wine prices’ mark-up in restaurants”, Journal of Wine Economics 13(2), 144-159.

Lockshin, L., Jarvis, W., d’Hauteville, F., & Perrouty, J. P. (2006). Using simulations from discrete choice experiments to measure consumer sensitivity to brand, region, price, and awards in wine choice. Food quality and preference, 17(3-4), 166-178.

McAfee, Preston (1995) “Multiproduct Equilibrium Price Dispersion” Journal of Economic Theory 67(1), 83-105.

Molico, Miguel, (2006) “The Distribution of Money and Prices in a Search Equilibrium”, internaitonl Economic Review, 47(3), 701-722.

Moraga-Conzalez, Jose-Luis, Z. Sandor, M. Wildenbeest, (2015), “Prices and Heterogeneous Search Costs” , Centre for Economic Policy Research Disucssion Paper 10657. June.

National Institute of Health (National Institute on Alcohol Abuse and Alcoholism) (2015) “Alcohol Facts and Statistics” access on December 14, 2019 at https://www.niaaa.nih.gov/publications/brochures-and-fact-sheets/alcohol-facts-and-statistics (full report available at this site). Latest data cited as 2015 in underlying reference but no date on brochure.

Oczkowski, Edward (1994) “A Hedonic Price Function for Australian Premium Table Wine”, Australian Journal of Agricultural Economics 38(1), 93-110.

Oczkowski, Edward (2017) “The Preferences and Prejudices of Australian Wine Critics” Journal of Wine Research 28(1), 56-67.

Office for National Statistics (2017) “Adult Drinking Habits in Great Britain: 2017” Statistical Bulletin.

Pennerstorfer, Dieter, Philipp Schmidt-Dengler, N. Schutz, C. Weiss, B. Yontcheva (2020) “Information and Price Dispersion: Theory and Evidence”, International Economic Review 61(2), 871-899.

Reichheld, Frederick, and Sasser, Earl (1990) “Zero Defections: Quality Comes to Services”, Harvard Business Review, September-October.

Reichheld, Frederick, and Schefter, Phil (2000) “E-Loyalty: Your Secret Weapon on the Web”, Harvard Business Review, July-August.

Remaud, H., Mueller, S., Cvyl, P., Lockshin, L., (2008) “Do Australian Wine Consumers Value Organic Wine?”, 4th International Conference of the Academy of Wine Business Research, Siena, 17-19 July.

Resendes, Stephanie, (2020) “Why Restaurant Customer Retention is Crucial to your Bottom Line”, Upserve. May 29. https://upserve.com/restaurant-insider/what-is-customer-retention-and-why-does-it-matter-for-your-restaurant/, accessed April 30, 2021.

Rhodes, Andrew and Zhou, Jidong (2015) “Consumer Search and Retail Market Structure” https://pdfs.semanticscholar.org/dcd1/89ea9f5659913335a3484a7a454c012a53c8.pdf

Robinson, Jancis (1997). Tasting Pleasure: Confessions of a Wine Lover. New York: Penguin Books.

Roma, Paolo, Di Martino, Giuseppe, and Perrone, Giovanni (2013) “What to Show on the Wine Labels: A Hedonic Analysis of Price Drivers of Sicilian Wines”, Applied Economics 45, 2765-2778.

Siriex, Lucie, Kledal, Paul, Sulitang, Turnsinbek (2011) “Organic Food Consumers’ Trade-Offs Between Local or Imported, Conventional or Organic Products: A Qualitative Study in Shanghai”, International Journal of Consumer Studies 35(6), 670-678.

Sorensen, Alan (2000), “Equilibrium Price Dispersion in Retail Markets for Prescription Drugs”, Journal of Political Economy 108(4), 833-850.

Stahl, Dale (1989) “oligopolistic Pricing with Sequential Consumer Search” American Economic Review 79(4), 700-712.

Stavins, Joanna, (2001) “Price Discrimination in the Airline Market: The Effect of Market Concentration”, The Review of Economics and Statistics, 200-202.

Stuen, E. T., Miller, J. R., & Stone, R. W. (2015). An analysis of wine critic consensus: A study of Washington and California wines. Journal of Wine Economics, 10(1), 47-61.

Syverson, Chad, (2007), “Prices, Spatial Competition and Heterogeneous Producers: An Empirical Test”, The Journal of Industrial Economics, LV(2), June. 197-222.

Van Nieuwerburgh, Stijn and Pierre-Olivier Weill (2010) “Why has House Price Dispersion Gone Up?”, The Review of Econoimc Studies, 77(4), October. 1567-1606

Verboven, Frank (1999) “Product Line Rivalry and Market Segmentation – with an Application to Automobile Optional Engine Pricing” Journal of Industrial Economics XLVII (4), 399-425.

Varian, Hal (1980) “A Model of Sales” American Economic Review 70(4), 651-659.

Wright, Randall and Wong, Yuet-Yee (2014), “Buyers, Sellers, and Middlemen: Variations on Search-Theoretic Themes”, International Economic Review 55(2), 375-397.

Zhou, Jidong (2014) “Multiproduct Search and the Joint Search Effect”, American Economic Review 102(7), 3249-3276.

Zhou, Jidong (2017) “Competitive Bundling”, Econometrica 85(1), 145-172.

Table 1 : Data: City, Chateaux, Restaurant Observations

Market	Observations	Chateaux	Restaurants
London	16041	458	187
Hong Kong	14520	242	148
New York	15833	390	242
Paris	17511	715	215
Los Angeles	5771	183	115
Total	69676	1988	907

Table 2: Panel Distribution

Survey Wave	Observations/Place	Percentage of Sample
	Paris	
December, 2011	2951	16.85
November, 2012	6970	39.80
December, 2013	7590	43.34
	New York	
March, 2011	4451	28.11
February, 2012	5746	36.29
March, 2013	5636	35.60
	Los Angeles	
March, 2011	1990	34.48
March, 2012	1918	33.24
March, 2013	1863	32.28
	London	
March, 2011	4723	29.44
January, 2012	5294	33.00
January, 2013	6024	37.55
	Hong Kong	
October, 2011	4202	28.94
April, 2012	4508	31.05
April, 2013	5810	40.01

Figure 1: Skewness of (Full) Dataset

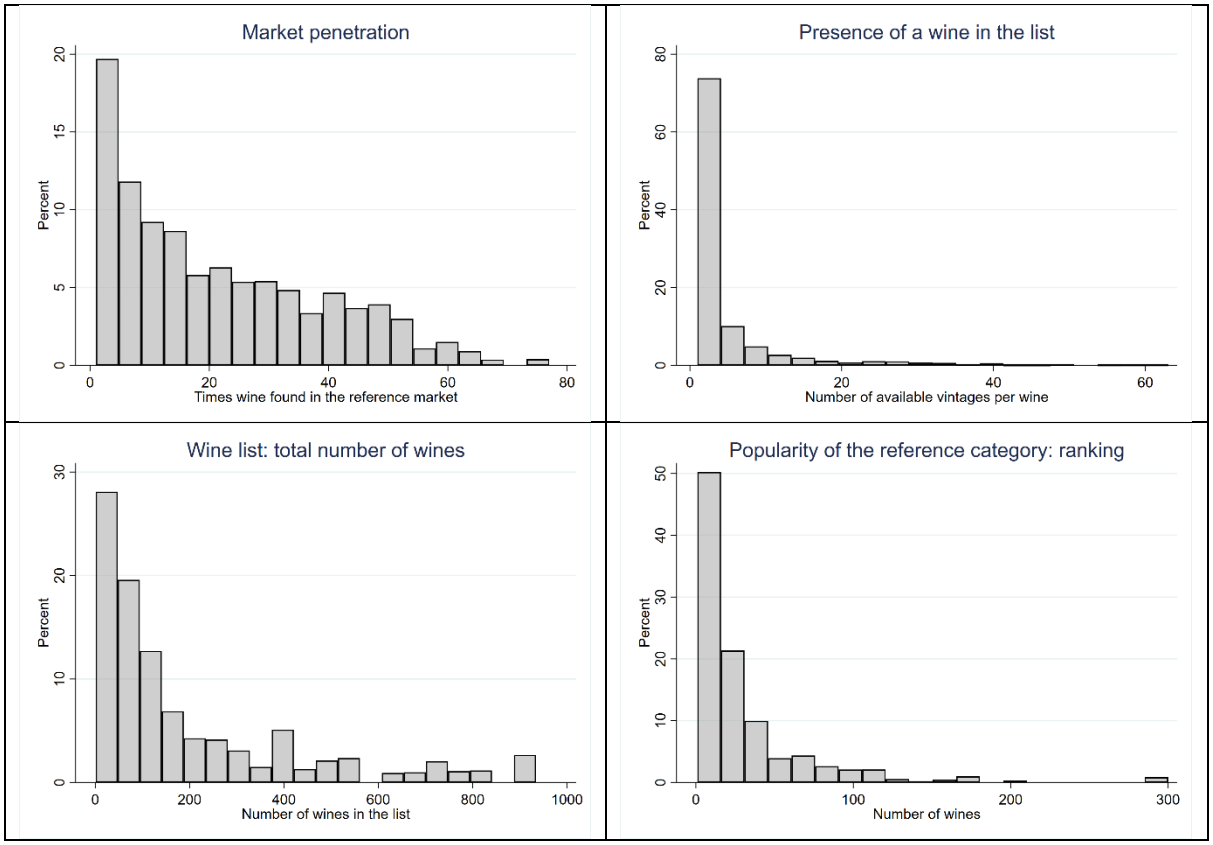


Table 3: (Reduced) Sample Characteristics

Market	Observations	Mean	S.D.	Min	Max	Skew	Kurtosis
Hong Kong	12,500	866.20	1481.80	11	28026	5.30	53.80
London	14,294	652.40	1281.20	20	26427	6.60	74.80
Los Angeles	5,068	454.00	737.80	9	11747	5.20	46.20
New York	13,583	608.50	930.00	16	11931	4.10	27.00
Paris	14,114	589.70	1232.50	14	23000	7.30	85.10
Total	60,137	655.20	1212.90	9	28026	6.82	80.79

Table 4: Markups (Lerner, %) for Six Iconic Bottles, 1961 Vintage

	Hong Kong	London	Los Angeles	New York	Paris
Margaux	65	57	8	67	67
Petrus	51	70	-	-49	40
Mouton	64	74	35	14	78
Latour	47	-	-2	-12	62
Haut Brion	50	28	20	18	36
Lafite Rothschild	49	39	-	50	-

Table 5 – (Residual) Price Level and Competition

	All	Paris	Hong Kong	London	Los Angeles	New York
In separate regressions:						
Competition (<1km)	0.002	0.004	-0.000	0.0008*	-0.008	0.001
	(0.82)	(0.86)	(-0.02)	(1.87)	(-0.56)	(0.11)
Competition (<10km)	-0.004	-0.000	-0.004	-0.006	0.009	-0.001
	(-1.65)	(-0.02)	(-1.03)	(-1.59)	(1.41)	(-0.25)
Competition (<120km)	-0.007	-0.001	-0.005	-0.008*	0.001	-0.002
	(-2.56)	(-0.33)	(-1.07)	(-1.75)	(0.07)	(-0.27)
Weighted Competition (<120 km)	-0.003	-0.000	-0.000	-0.003	0.005	-0.000
	(-1.17)	(-0.10)	(-0.01)	(-0.80)	(0.89)	(-0.01)
Observations	60,137	14, 114	12,500	14,294	5,068	13,583

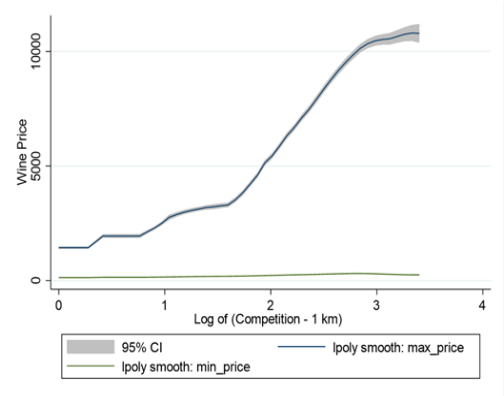
Controls added for city in "all" regression, time period, wine list characteristics, quality rating, location, cuisine, and ambiance.
Robust t-statistics in parentheses. ***p<0.01 **p<0.05 *p<0.10

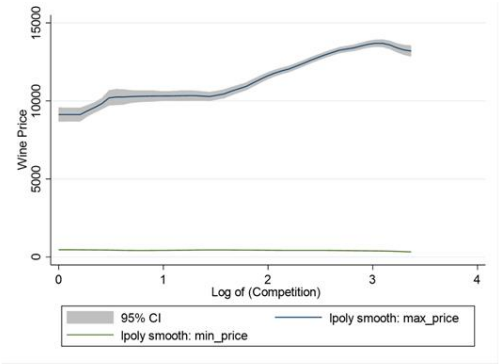
Table 6 - Second stage regressions

Variable	All		Paris		Hong Kong		London		Los Angeles		New York
Density < 1Km.	0.108*** (4.78)		0.124*** (2.78)		0.211*** (3.43)		0.148*** (4.61)		0.201* (1.75)		0.260*** (6.92)
Density < 120 Km.		0.128*** (7.11)		0.332*** (8.80)		0.352*** (6.33)		0.216*** (6.60)		0.349*** (7.01)	
Vintages per wine	0.246*** (7.59)	0.200*** (6.26)	0.440*** (11.35)	0.267*** (6.33	0.312** (6.14)	0.163** (2.78	0.244* (5.24)	0.169** (3.10)	0.378** (4.32	0.154* (1.85)	.161*** (2.95)
Length within Category	-0.172*** (-10.39)	-0.144*** (-8.43)	-0.230*** (-7.37)	-0.119*** (-4.89)	-0.258*** (-8.36)	-0.197*** (-6.25)	-0.148*** (-5.41)	-0.085*** (-3.24)	-0.215*** (-2.64)	-0.143* (-1.75)	-0.207*** (-6.17)
Winelist Length	0.188*** (6.69)	0.180*** (6.62)	0.173*** (2.90)	0.143** (2.51)	0.177*** (3.16)	0.175*** (3.42)	0.243*** (5.12)	0.247*** (5.45)	0.056 (0.51)	0.054 (0.51)	0.318*** (7.85)
Wine Spectator Award	0.057 (1.10)	0.065 (1.30)	0.111 (0.96)	0.132 (1.21)	0.029 (0.23)	0.037 (0.31)	-0.165* (-1.72)	-0.190** (-2.07)	0.126 (1.01)	0.126 (1.04)	0.009 (0.12)
One Star	-0.056 (-0.71)	-0.054 (-0.73)	0.248 (1.55)	0.195 (1.27)	-0.103 (-1.19)	-0.078 (-1.08)	-0.006 (-0.05)	0.012 (0.11)			-0.103 (-1.06)
Two Stars	-0.136 (-1.33)	-0.106 (-1.07)	-0.380 (-1.65)	-0.362* (-1.69)	-0.427*** (-3.42)	-0.359*** (-3.33)	-0.051 (-0.44)	-0.040 (-0.34)			-0.005 (-0.02)
Three Stars	0.051 (0.41)	0.078 (0.59)	-0.543 (-1.62)	-0.620* (-1.84)	-0.292** (-2.11)	-0.050 (-0.39)	0.094 (0.89)	0.116 (0.82)			-0.294** (-2.24)
Controls for City	X	X									
Controls for Colour, Format, Time	X	X	X	X	X	X	X	X	X	X	X
Constant	-3.634*** (-23.85)	-3.892*** (-25.43)	-4.425*** (-16.30)	-4.953*** (-19.04)	-4.421*** (-13.64)	-5.148*** (-14.66)	-4.767*** (-21.57)	-5.230*** (-21.09)	-3.303*** (-9.27)_	-4.044*** (-11.76)	-4.731*** (-24.65)
Observations	60137	60137	14114	14114	12500	12500	14294	14294	5068	5068	13583
R^2	0.037	0.038	0.060	0.070	0.044	0.051	0.039	0.042	0.040	0.051	0.050

Robust t-statistics in parentheses. ***p<0.01 **p<0.05 *p<0.10

Figure 2a: Raw Price Dispersion and Competition: All, Iconic, and Ordinary Wine Ranges





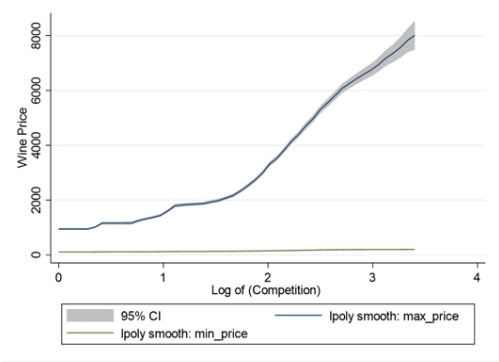
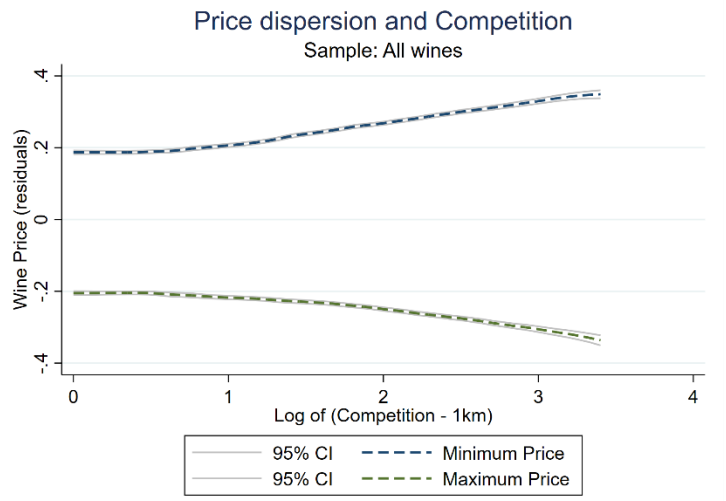
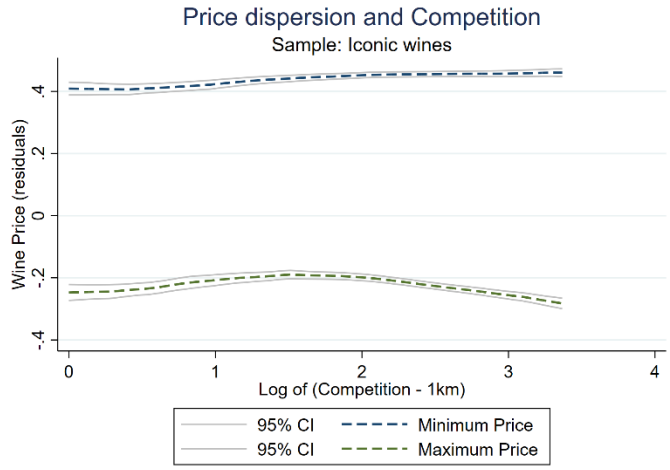


Figure 2b: Stripped Price Dispersion and Competition: All, Iconic, and Ordinary Wine Ranges




Price dispersion and Competition
Sample: Iconic wines
Wine Price (residuals)
-.4
-.2
0
.2
.4
0
1
2
3
4
Log of (Competition - 1km)
95% CI
Minimum Price
95% CI
Maximum Price

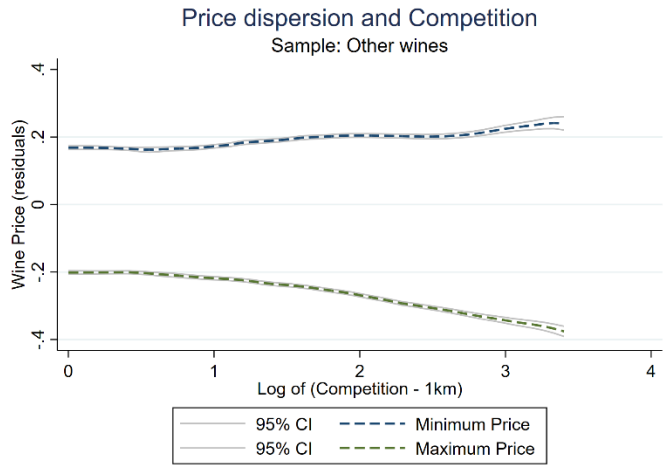

Price dispersion and Competition
Sample: Other wines
Wine Price (residuals)
-.4
-.2
0
.2
.4
0
1
2
3
4
Log of (Competition - 1km)
95% CI
Minimum Price
95% CI
Maximum Price

Table 7: Iconic versus Ordinary Results

Variable	Iconic		Ordinary	
Density < 1Km.	-0.030 (-0.86)		0.073*** (3.01)	
Density < 120 Km.		-0.117*** (-2.85)		0.071*** (3.92)
Vintages per wine	-0.037 (-0.65)	0.015 (0.24)	0.188** (4.62)	-0.155*** (-8.85)
Length within Category	0.019 (0.43)	0.010 (0.22)	-0.167*** (-9.69)	-0.155*** (-8.85)
Winelist Length	0.188*** (3.75)	0.157*** (3.06)	0.220*** (8.27)	0.216*** (8.21)
Wine Spectator Award	-0.022 (-0.27)	-0.027 (-0.34)	0.047 (0.85)	0.053 (0.96)
One Star	-0.054 (-0.59)	-0.056 (-0.62)	-0.076 (-1.10)	-0.077 (-1.12)
Two Stars	-0.039 (-0.41)	-0.042 (-0.45)	-0.121 (-1.06)	-0.102 (-0.91)
Three Stars	0.041 (0.36)	0.030 (0.27)	0.079 (0.55)	0.094 (0.64)
Controls for City	X	X	X	X
Controls for Colour, Format, Time	X	X	X	X
Constant	-3.680*** (-16.98)	-3.287*** (-12.90)	-4.399*** (-27.59)	-4.488*** (-28.12)
Observations	19,311	19,311	40,758	40,758
R^2	0.017	0.018	0.028	0.028

Robust t-statistics in parentheses. ***p<0.01 **p<0.05 *p<0.10

APPENDIX

We must check that the assumptions under which our equilibrium value was obtained are indeed justified in equilibrium. In particular, since we assume that some connoisseurs will switch restaurants in the second period we need :

$$P_1^* > V_T$$

Substituting from the expression for the optimal P_1^*, solving, and requiring that the equilibrium condition for price dispersion to increase with competition holds, we obtain that the condition for this to hold is that:

$$\frac{2t(\alpha+\mu(1-\alpha))(1+\delta(1-\mu))}{\Delta-\delta(1-\gamma)^2[2\big(\alpha+\mu(1-\alpha)\big)+\mu(1+\alpha)]} > V_T$$

While this condition is not easy to interpret, a minimum condition for this to be possible requires that the left-hand side of this expression is positive or:

$$\frac{\alpha+\mu(1-\alpha)}{(1+\alpha)\mu} < (1-\gamma)^2$$

Roughly speaking, this is more easily satisfied if γ is relatively small for the large μ that we require in equilibrium (or equivalently, that a larger meal ticket compared to the wine ticket makes this easier to satisfy for smaller γ). As we use the fully symmetric case as our touchstone in the paper, this condition requires, that the meal ticket be

We also need to ensure that each restaurant would actually set the price of the « tourist » bottle at the tourist's expectation prices. Clearly, given that consumers expect the bottle to be priced at V_T there is no incentive for the restaurant to price lower than this. Given the price expectation, setting a lower price would not attract any additional consumers: tourists disappear after one period and the connoisseurs who find their bottle at or below the expectation of V_T would stay put anyway. This means that we only need to check that it would not pay to actually charge a price higher than the expected price V_T.

By charging a higher price, the restaurant loses the margin from all wine sales to tourists who would purchase at the outlet. Recalling that we express prices charged as net prices, this loss is worth $\alpha\gamma(1+\delta)\frac{V_T}{2}$. What would be the gain? If the price charged for the tourist bottle, P_T is such that $P_T < P_1^*$, half the first period connoisseurs would purchase the tourist bottle (bottle 2), since half prefer each bottle type. Given symmetric expectations about prices these connoisseurs all stay put in the second period so, by charging a higher price the restaurant makes the following gain on these consumers $\frac{1-\alpha}{4}\gamma(1+\delta)(P_1^*-P_T)$. Finally, the tourist wine will also be consumed by « migrants » from the second platform. The higher price charged to these is worth $\delta(1-\gamma)\frac{1-\alpha}{4}(P_1^*-P_T)$. So overall our equilibrium with P_1^* and the other bottled priced at V_T holds when the following expression is true and, in particular, that this expression holds when $P_T = V_T$, as this minimises the left hand side:

$$\frac{V_T}{P_1^* - V_T} > \frac{(1-\alpha)}{2\alpha\gamma}\frac{(\gamma+\delta)}{(1+\delta)}$$

This means that the margin made when pricing at the tourist reservation price must be large enough compared to the gap between the price of the other wine and this reservation price for our argument in the text to hold as stated. The expression for P_1^* from the text can be substituted into the expression above to get an expression in terms of the primitives of the problem, producing an expression for the bounds on the primitives of the problem that would need to hold for V_T to be the optimal selection for P_T. This expression is composed of a numerator that is negative if we assume the condition that for dispersion to increase with competition holds. The denominator cannot be signed easily offhand, as it involves a positive term minus a second positive term. The total is guaranteed to be positive if $\mu\delta(2\gamma - 2\alpha - \gamma^2(1+\alpha) + 2\alpha\gamma) + 2\delta\alpha > 0$. This will always hold for the parameter ranges we have assumed in the work, however, and in particular with α and γ between 0 and 1. Hence, guaranteeing that V_T is positive is sufficient to guarantee the rest.