

Unbridled Spirit: Bourbon markets, pricing, and investment

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Abstract

The market for bourbon whiskey is booming. Demand is so great that bourbon aficionados regularly line up overnight for the chance to purchase just one bottle and many high-end bourbons are allocated to consumers only via lotteries. The prevalence of such non-price allocation mechanisms, however, naturally leads to profitable reselling in secondary markets. We examine how such secondary markets work, and bourbon's potential as an alternative investment, using two unique data sources. First, we develop a price index for rare and vintage bourbons using 2011 to 2019 data from an online auction-house. Using a repeat sales regression framework, our estimates show that bourbon prices increased by about 9.1% per year over the sample period suggesting that bourbon has the potential to be a unique alternative investment opportunity - similar to wine or fine art. We complement those estimates by developing a second price index using data from a decentralized peer-to-peer secondary market that operated on a major social network from 2014 to 2017. We show that our auction and peer-to-peer data feature similar price increases over the sample period and relatively similar returns to observable product characteristics suggesting (1) little opportunity for arbitrage between these distinct markets and (2) that the law of one price can prevail despite remarkably different institutional features. When examining bourbon's potential as an alternative investment, we find that the addition of bourbon can improve the risk-return ratio of typical stock/bond portfolios, at least during our sample period.

Keywords: Bourbon, Whiskey, Alternative Investment, Price Index, Gray Markets, Secondary

JEL: L66, G11, G14, L14, K42

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1 Introduction

After decades of decline, bourbon whiskey has experienced a remarkable recent resurgence. In response to bourbon's renewed popularity, larger distilleries have invested millions of dollars to expand production and craft whiskey distilleries have reappeared in the American market.¹ In 2017, the *New York Times* referred to this turnaround as "the bourbon boom."² Since then, bourbon's popularity has continued to grow with the American Craft Spirits Association reporting that there were 2,046 craft distilleries as of August 2019, an 11.5% increase compared to August 2018.³ As part of this widespread renewal of interest, sales of rare bourbon have become common at major auction houses. For example, 34 bottles of 24-Year-Old Blade and Bow bourbon sold for \$95,550 at Christie's in New York City in December of 2016.⁴ At nearly \$3,000 per bottle, the role of consumption in this transaction is questionable and bourbon's potential as an alternative investment becomes apparent.⁵

Outside of major auction houses, secondary markets - including online auction sites and private groups hosted on major social networks - are also thriving.⁶ Even though selling alcohol without a license is not lawful in the United States, these secondary markets are prevalent because few distillers, distributors, or retailers have responded to surging demand by increasing retail bourbon prices. Notably, the market is dominated by the bourbons produced by a small group of long-standing incumbents: Heaven Hill, Jim Beam, Maker's Mark, Four Roses, Buffalo Trace, Brown-Forman/Woodford Reserve, and Wild Turkey. These companies produce several times more bourbon than all other American distilleries combined, and each has a number of highly-coveted expressions. It is their aversion to increasing prices for their most-popular bourbons that creates shortages and leads to reselling in secondary markets.

¹See https://kybourbon.com/wp-content/uploads/2019/02/KDA-BourbonBoomSheet_2019.pdf.

²See this *New York Times* article - <https://www.nytimes.com/2017/07/11/opinion/will-trump-kill-the-bourbon-boom.html>.

³For more, see <https://americancraftspirits.org/wp-content/uploads/2017/02/ACSA-2019-Annual-Report.pdf>, <http://whiskyadvocate.com/why-bourbon-prices-got-higher/>, and <http://www.discus.org/us-bourbon-and-tn-whiskey-drive-export-records-in-2013/>.

⁴See <http://www.christies.com/lotfinder/Lot/one-barrel-of-blade-and-bow-single-6051424-details.aspx>.

⁵The term "alternative investment" tends to be used as a catch-all for assets other than stocks and bonds. Some alternative investments, such as real estate, private equity, and derivatives contracts, are quite similar to traditional financial assets while others are perhaps better-described as "collectibles," such as wine, fine art, sports memorabilia, stamps, antique furniture, cigars, and so on.

⁶See <https://www.marketplace.org/2017/06/14/business/bourbon-market-heats-creating-black-market-demand>.

We characterize secondary markets for bourbon by considering two related research questions. The first asks whether bourbon ought to be considered as a collectible item or as a viable alternative investment. Our second research question examines whether secondary markets can be efficient despite their legal standing and unusual institutional features. The operation of these markets is of particular interest because unlawful nature ensures that market participants face unusual risks. For example, sellers and buyers cannot rely on any external authority to enforce property rights and, at least in the United States, packages containing alcohol can be seized for violating both shipping and licensing restrictions.⁷ To help us study these markets, we employ unique data on bourbon prices from a “centralized” auction-house setting (whiskyauction.com). That data consists of over 10,000 auction sales occurring between April 2011 and October 2019. We further explore secondary markets for bourbon using data on 3,300 sales that occurred between 2014 and 2017 in a “decentralized” private group (named “Strong Water Trading”) on a well-known social network. We describe how whiskyauction.com and Strong Water Trading operate in later sections.

Using a repeat sales regression framework (Bailey et al., 1963), we find that bourbon prices increased by about 9.1% per year from 2011 to 2019 in our whiskyauction.com data.⁸ The average across the sample period disguises the fact that much of the overall price increase occurred between 2014 and 2018. In particular, between August 2014 and January of 2018, we estimate annual price increases of about 18% per year. In our Strong Water Trading data, we find that bourbon prices increased by just under 20.4% per year during the sample period (October 2014 to November 2017). These estimates suggest that our centralized and decentralized markets for bourbon feature quite similar price increases, at least during the sample period, and that even legally-questionable markets can operate efficiently. While we only have hedonic product characteristics for some of the records in our data, when we examine how such product characteristics - age, alcohol content, and so on - affect prices, our estimates suggest that these characteristics have similar qualitative effects on prices regardless of the data we use, again illustrating that secondary markets can operate efficiently despite their unique nature.

⁷Companies such as FedEx and UPS explain that regular customers cannot ship alcohol, but often provide exceptions for those who are appropriately licensed. See <https://www.fedex.com/en-us/shipping/alcohol/shipping-requirements.html> and <https://www.ups.com/us/en/help-center/packaging-and-supplies/special-care-shipments/wine.page>. The U.S. Postal Service does not grant any such exceptions - https://pe.usps.com/text/pub52/pub52c4_006.htm. Each link last accessed on 9/30/2020.

⁸Specifically, the index value at the end of the sample period is 2.004, suggesting a 9.1% rate of return on an annual basis over the eight-year sample period.

Our findings imply that bourbon could present a viable alternative investment opportunity. Whether any particular asset, however, is a valid alternative investment - or merely a “collectible” - depends on how the asset’s rate of return compares to other investment options. In particular, Burton and Jacobsen (1999) explain that collectibles have lower returns relative to non-collectible assets with similar risk, because there is usually a non-pecuniary benefit to owning the item. For example, wine and art can be consumed, displayed, or otherwise enjoyed whereas shares and bonds provide no comparable benefit. If bourbon was merely a collectible, secondary bourbon markets would feature mild price increases over time (as in the market for fine art, wine, or baseball cards - excepting a few unique cases; see Baumol, 1986). Such secondary markets would therefore exist primarily to allocate bourbon among those who value the product for non-pecuniary reasons (e.g., they want to display, gift, or consume the product). Instead, secondary markets for bourbon show persistent large price increases, suggesting that bourbon ought to be considered as a viable alternative investment opportunity.⁹

Focusing on bourbon’s investment potential, when we compare the rate of return implied by our bourbon price index to returns in traditional financial assets, we see that bourbon’s real arithmetic return is higher than a variety of stocks, bonds, and other commodities over our sample period. Although, because of greater variance, we acknowledge that bourbon’s risk-adjusted returns are significantly less appealing. On the other hand, our analysis shows that while bourbon returns are volatile, they exhibit low correlation with movements in the prices of other financial assets. From a portfolio diversification standpoint, therefore, adding approximately 5% bourbon to a typical stock/bond portfolio would significantly improve the risk-return ratio of the portfolio.

We proceed as follows. In Section 2 we examine the literature regarding, and the methods used to study, markets for collectibles and alternative investments. We also provide further background on secondary markets for bourbon. In Section 3, we describe our data and estimation framework. We present our empirical findings in Section 4 and conclude in Section 5.

⁹Particularly so if legislation further relaxes the rules on reselling small quantities of rare and vintage bourbons as has happened recently in Kentucky: <https://www.nbcnews.com/business/consumer/check-grandma-s-attic-vintage-bourbon-now-legal-sell-probably-n743066>

2 Background

Burton and Jacobsen (1999) examine the literature on collectibles in a review article for the *Journal of Economic Perspectives*. Their review examines the methods, data, and findings of studies that consider returns on art, wine, antiques, ceramics, coins, stamps, books, and even “Beanie Babies.”¹⁰ Burton and Jacobsen emphasize that a key empirical challenge in this literature is the fact that sales of collectibles tend to be rare and are not always of an identical item. For what appear to be identical products, the sale price may depend on hard-to-observe details such as the identity and reputation of a seller (or buyer), minor differences in the item’s condition, vintage, provenance, or the presence of a guarantee of authenticity.

Authors have tried to address such barriers to measurement using three primary approaches. The first is to create composite indices by selecting sets of items whose prices will be measured and averaged over time. This method is subject to the same biases as indices such as the Consumer Price Index and therefore sensitive to the choice of items in the initial basket and changes in the “representative basket.” Goetzmann (1996) harnessed some of the drawbacks of this method to examine the consequences of survivorship in the high-end art market whereas Auer and Schuhmacher (2013) use this approach to examine the investment performance of diamonds. A second potential approach is hedonic in nature and attempts to control for objective features of collectibles such as their size or location. This approach is ideal for something like real estate where characteristics are easily observed (such as the number of bedrooms, bathrooms, neighborhood, and so on). Ashenfelter et al. (1995) use this kind of hedonic analysis to examine the relationship between the price of young Bordeaux wine and the weather during its growing season. More recently, Dobrynskaya and Kishilova (2018) use a hedonic approach to study the returns to investing in LEGO. They find real returns of at least 8% over the past two decades leading the authors to confirm LEGO as “the toy of smart investors.”

A third approach creates a repeat sales price index that accounts for the price of similar but perhaps not identical items when there are a variety of types of a given collectible. This approach involves the use of sales data on many similar items over an extended period of time. As just one

¹⁰As Alan Krueger noted in his *New York Times* column in 2005, “[t]he resale price of Beanie Babies ... grew at an astonishing rate of 140 percent a year from 1994 to 1999 and has since crashed.” See <http://www.nytimes.com/2005/06/23/business/are-collectibles-the-new-real-estate.html>.

example, Baumol (1986) used repeated sales of many paintings from 1652 to 1961 and estimated that the rate of return on fine art was about eight percentage points below the rate of return on stocks over the same period. Goetzmann (1993) extended that analysis to 1987. Graddy and Margolis (2011) use a repeat sales approach to study returns to investment in antique violins, finding a 3.5% real annual return. Dimson and Spaenjers (2011) also use repeat sales approach to determine that the return to investing in stamps was 2.9% in real terms from 1900 to 2008 while Dimson et al. (2015), again using the repeat sales approach, study the investment performance of Premier Cru Bourdeaux wine from 1900 to 2012, finding a 4.1% real return. These authors use a repeat sales approach because it is ideal for calculating a broad rate of return on a group of similar collectibles such as wine, stamps, and, in the case of this paper, bourbon. We explain the repeat sales method further in Section 3.

Regardless of the approach taken, and as we see in more recent estimates for the returns on collectibles, Burton and Jacobsen (1999) find that “[t]he majority of collectibles yield lower financial returns than stocks, and studies that include a measure of variability over time uniformly find that collectibles embody more risk than most other financial assets.” Dimson and Spaenjers (2014) echo such a sentiment finding that collectibles “have outperformed government bonds, Treasury bills, and gold over the long run” while cautioning that from an investment perspective such assets are “attractive only to investors who already have a diversified portfolio of financial assets, who have a long investment horizon, and who can sit out periods of high illiquidity and low demand for luxury consumption.” In sum, the literature implies that investors who buy and hold collectibles are likely doing so, at least in part, for non-pecuniary reasons - they value ownership of the collectible, in addition to being interested in returns on investment. In turn, this means that if the rate of return is low and the risk is high relative to traditional assets, bourbon should also be considered as a collectible item, purchased and held mainly for its non-pecuniary benefits. If the rate of return on bourbon is high and the risk is low, then it might be better viewed as an alternative investment. Of course, sale prices, and therefore both risk and return, are dependent upon the unique and evolving institutional details of the secondary market for bourbon. Such markets are, strictly speaking, prohibited by state and federal law in the United States, adding further risk to secondary bourbon markets.

Despite the additional risk, bourbon aficionados often turn to secondary markets to obtain coveted products because producers are reluctant, for whatever reason, to significantly raise retail prices, leading to shortages. Two examples illustrate the extent to which distillers are averse to nominal price increases. The first is the case of Maker’s Mark who, on February 9, 2013, announced that in order to satisfy surging demand they would reduce alcohol content from 90 proof to 84 proof (45% to 42% alcohol by volume) within their iconic wax-dipped bourbon bottles. They chose to try to “stretch” their existing stock rather than simply raising prices. Note that they could not simply ramp up production; bourbon’s aging process ensures that supply is highly inelastic in the short-run. Customers reacted so vehemently against the idea that Maker’s Mark had to backtrack on the decision a week later.¹¹

A second example is the annual release of the infamous “Pappy Van Winkle” line from Buffalo Trace. The Van Winkle line includes several “expressions” of varying ages (15, 20, and 23 year-old bourbons along with three “brand extensions”: Old Rip Van Winkle, Van Winkle Family Reserve Rye, and Van Winkle Family Reserve 12-Year). The number of bottles of each expression is limited and many liquor stores around the United States do not receive any Van Winkle products in a given year. Instead of raising prices to market-clearing levels, however, stores that receive a bottle from the Van Winkle line tend to hold lotteries or charity raffles to award someone the right to buy that bottle. The “winning” customer typically pays only the suggested retail price, ranging from \$70 to \$300 depending on the particular bottle.¹² Stores also use charity raffles, lotteries, or simply long lines (often overnight and sometimes stretching to several days) to ration limited releases such as the Buffalo Trace Antique Collection (an annual release of five whiskeys - George T. Stagg, Thomas H. Handy Rye, Eagle Rare 17, Sazerac 18 Year Rye, and William Larue Weller), Heaven Hill’s Parker’s Heritage Collection, and Four Roses’ Small Batch Limited Edition series, among many others. Such allocation mechanisms ensure that those who obtain limited releases from retailers are not those who have the highest willingness-to-pay (in dollars). Unsurprisingly, these are the kinds of bottles that are easily resold for a significant profit in bourbon secondary markets. Selling a bottle via a middleman, such as whiskyauction.com, is one option, but selling directly in peer-to-peer secondary markets avoids the middleman’s commission (10% in the case of whiskyauction.com).

¹¹See https://www.washingtonpost.com/lifestyle/food/makers-mark-debacle-the-proof-is-in-the-overreaction/2013/02/25/0aba8564-7c32-11e2-9a75-dab0201670da_story.html?utm_term=.ec5b9e4d5060 for more on this story.

¹²See <http://bourbonr.com/blog/2019-pappy-van-winkle-announced-with-a-warning/>.

Delving a little deeper into peer-to-peer secondary markets, these groups appear to rely on reputation and norms to operate effectively. For example, in contrast to whiskyauction.com, those who wish to participate in a peer-to-peer market first have to be referred by existing members. Sellers and buyers also typically provide personal references when trading with one another for the first time. When selling, group members post their item for sale in the group by making a post that includes pictures, any necessary information regarding the bottle’s condition or special features (a distiller’s signature, for example, or some other unique attribute), a “buy-it-now” (BIN) price, and details of shipping options and their associated cost. Under typical group rules, the first person to comment “BIN” enters into a binding agreement to purchase the product at the stated price. Until someone chooses the BIN option, the seller can accept offers below the BIN price at any time. Payment is facilitated by PayPal, Zelle, and Venmo. Side conversations, including private messages, are strictly forbidden to ensure there is a public record of prices and transactions.¹³ Buyers or sellers who fail to meet the agreed terms of a deal are warned and subsequently banned from the groups by unpaid and largely anonymous administrators/moderators.

We use data from one particular group, humorously titled “Strong Water Trading.” At its peak, Strong Water Trading had over 6,000 U.S.-based members. It was eventually shut down because it operated in clear violation of the terms of service for the social network in question. Replacement groups quickly emerged, however, and at the time of writing there are a wide array of bourbon groups that serve broad and narrow segments of the market, including some that serve particular geographic areas or focus on certain product categories (such as products from a single distillery, time period, or with certain taste profiles). Strong Water Trading, as one of the earliest examples of an online bourbon trading community, uniquely required members to record sales in a publicly-available spreadsheet. It is not clear why sales were recorded, particularly because the records do not provide the identity of the buyer and the seller, which could help to establish reputation. Such records, however, might help to establish pricing benchmarks that could reduce antagonism among members. Replacement groups do not appear to require sales to be recorded and this is why we only have repeat sales data for the years 2014 to 2017. From time to time, these replacement groups are also purged from the social network for violating the network’s terms of

¹³It is against the network’s terms of service to “scrape” that data. Moreover, it would be very challenging to parse the conversation, particularly because participants tend to use language and images/emojis designed to avoid detection by network algorithms.

service. Alas, the groups appear to return quite swiftly under modified names and rules (especially regarding words not to be used) to help avoid detection by algorithms.¹⁴

The fact that these groups can function relatively smoothly is quite remarkable, especially given they cannot resort to violence to enforce property rights due to the physical distance between participants. Indeed, these markets stand in contrast to Donohue and Levitt (1998) who suggest that violence is likely to be the substitute for enforceable contracts and well-established property rights. We describe our data and our approach to creating a bourbon price index in the next section.

3 Data and Empirical Framework

3.1 Data

As we mention earlier, our first data source involves bourbon sales records from www.whiskyauction.com. The website is one of several similar auction sites but this data is valuable because the website has a global presence, appears to be legally permissible in its jurisdiction, and provides over eight years of data on bourbon auction prices. Note that the site operates strictly as a middleman and only auctions items actually in their (temporary) possession.¹⁵ The company appears to be located in Germany and claims that there are relatively few restrictions on where they can ship to. For the United States, they say they can ship to most states (those they could not ship to during the time period studied were Alabama, Arkansas, Iowa, Kentucky, Mississippi, New Hampshire, North Dakota, Pennsylvania, and Utah).¹⁶

We summarize our www.whiskyauction.com data in Table 1, presenting information on sale prices, whiskey age, proof ($= 2 \times$ percent alcohol by volume), and summary information on sales per product. Because our analysis relies on “repeat sales,” we exclude products that appear only once in the data ($= 1,960$ records). We collected this data in November 2019 and organized it using a variety of text analysis tools designed to extract the hedonic characteristics of each product,

¹⁴See <https://www.whiskyadvocate.com/black-market-bourbon-feature/> for a recent update on such groups.

¹⁵Sellers send their products to the company, the company then places the item up for the auction (including taking a standard set of high quality pictures), collects payment, and ships the product to the buyer. Sellers get paid a few days after the auction ends and the site makes money from a 10% commission on sales. More info at https://whiskyauction.com/auction/vendor_e.html.

¹⁶Importing a single bottle for personal use is legally possible but only if using a courier service. Shipping alcohol by mail is strictly prohibited. Rules and associated custom duties vary by state, see https://help.cbp.gov/app/answers/detail/a_id/212/~/requirements-for-importing-alcohol-for-personal-use. Last accessed 7/20/2020.

including sale prices, age, alcohol content, and so on. We then manually checked the data for any remaining errors.

Throughout, we focus only on sales records relating to “750ml” or “fifth” (referring to the bottle being about a fifth of a U.S. gallon) size bottles. The lone exception to that rule is Blanton’s, which is always sold as a 700ml bottle. Other sizes are not common, particularly for highly-regarded products, and usually do not appear more than once in the data in any case. In the summary statistics we see that average sale prices increase markedly after 2013 but there is a slight decline in 2019. However, notice that the average age of products sold peaks in 2014 and is close to its minimum in 2019. The same pattern is true for proof (= a measure of alcohol content, where 100 proof equals 50 percent alcohol by volume). Typically, higher proof and more mature bourbons have higher retail prices in primary markets, which helps to explain why average prices are down in 2019. Finally, we present summary information on sales per product. For sales per product, note that the mean refers to the average number of sales of each product in a given year, conditional on appearing more than once across the sample period (that is why the minimum in a given year can be 1). For example, in 2018, we have about 11 sales records per unique product. Note that this does not mean the exact same bottle is sold 11 or more times in a year. Instead, we consider repeat sales to be sales of products with the same name, proof, and years of maturity (age) as another record. In economic terms, that means that a sale is considered a repeat sale only if the products are perfect substitutes. As a specific example, any given bottle of 2016 Pappy Van Winkle 23-Year-Old is, for all intents and purposes, a perfect substitute for any other Pappy Van Winkle 23-Year-Old from 2016. In contrast, Pappy Van Winkle 23-Year-Old from 2017 is not a perfect substitute for the 2016 vintage.

Our analysis also takes advantage of data from Strong Water Trading, a decentralized secondary market operated by U.S. bourbon aficionados on a major social network from 2014 to early 2018 (although we have “repeat” sales through November 2017 only). In Table 2, as in Table 1, we report summary statistics only for products that are observed more than once in our SWT data.¹⁷ Note that while the data from SWT is well-organized and very detailed it is harder to analyze than the whiskyauction.com data because members tend to communicate using colloquial, group-specific bourbon terms. The auction website data is easier to manipulate using text analysis because the site

¹⁷The restriction to repeat sales excludes a number of products sold only once in the time period studied. These items are often unique/vintage products such as antique medicinal whiskey bottles from the prohibition era or bottles with one-off designs, unusual sizes, or that possess celebrity/distiller signatures.

uses a standard listing format. When looking at our SWT data, we continue to focus on “fifth” size bottles (750 ml), excluding 363 observations of bottles of varying alternate sizes (handles, shoulders, and mini/airplane size bottles). Again, many appear in these less common sizes only once in the data. When appropriate, we adjust reported sale prices to exclude the cost of shipping.¹⁸ Finally, about 1,200 of the SWT records have an associated note that explained the deal was part-trade or that the price included a “taster” of some other bourbon, and so on. Other notes stated that the sale later “fell through” or that the bottle (rather than its contents) was unique in that the bottle had some kind of celebrity or distiller signature or a quirky packaging error/ flaw that made this particular bottle different to otherwise similar bottles in the data set. For our estimation sample, whenever these notes indicated that a sale was not comparable to others we eliminate the observation from the sample.

In the summary data, we can see that the Strong Water Trading group featured sales of products that had higher alcohol content and were aged longer prior to bottling (relative to the whiskyauction.com data). As both age and proof tend to be positively correlated with a whiskey’s desirability, it is not surprising to see that the average sale price is higher across the 2014 to 2017 period in our SWT data, relative to the whiskyauction.com data.

The advantage of using two distinct data sources is that it allows us to compare outcomes from a peer-to-peer decentralized unlawful market with those of a centralized and lawful auction house. Such an analysis, however, requires an apples to apples comparison and it is clear that the products being sold in these two markets are different. The repeat sales regression approach can help deal with differences in the type of product for sale in each market, but if changes in bourbon prices are concentrated among older, higher-proof expressions then returns in the two markets will likely differ. Moreover, it is worth noting here that these transaction records exist only because members of the SWT group were “required” to document all sales or trades that occurred and that compliance may have been imperfect. Further, because SWT sales data occur among members of a private and relatively geographically-concentrated group the data is potentially not representative of the bourbon market as a whole. On the other hand, the open nature of sales (“private” deals are not

¹⁸SWT records indicate whether shipping was included or excluded from the price and how much shipping cost (typically the cost is a flat rate \$10 in the continental U.S.). In our auction data, shipping costs are determined after the auction is over based upon the winner’s location. Therefore, shipping costs are not included in the sale price and are not available at all in the data.

allowed and are cause for a warning and subsequent expulsion from the group) might allow for efficient price discovery, once the market is sufficiently “thick,” and could work to preclude arbitrage opportunities between different secondary markets.

To provide just a little further context, Figure 1a illustrates how prices have changed over time for three bourbons released in the fall of 2014 - George T. Stagg (GTS), Old Rip Van Winkle (ORVW), and Four Roses Small Batch Limited Edition (4RSmBLE). These three are the most common products appearing in the SWT data and had retail prices at time of release of \$80, \$50, and \$100, respectively. The figure shows how the SWT secondary market quickly established a different price for each bourbon - there is a flurry of activity with lots of observations. Over time, activity diminishes. This pattern characterizes all of the annual release bourbons observed in our data (although more recent releases have had less time for activity to diminish). There are several potential explanations for this pattern: bottles could have reached investors who plan to buy and hold for a long time, many of the finite number of bottles have been consumed, or new bourbons deflect attention from the 2014 releases. Most strikingly, it is clear that returns are variable even for frequently traded products: some bourbons appreciate considerably while others remain at or around their initial secondary market price.

Figure 1b illustrates prices from 2015 to 2019 for 2014 GTS and 2014 4RSmBLE. We cannot include 2014 ORVW because our auction data does not provide enough information to separate 2014 ORVW from other years’ ORVW releases. Indeed, SWT data typically provides much more information on each product, allowing us to identify repeat sales with greater granularity. Taking ORVW as an example, our SWT data can identify each year’s release as a unique product whereas our whiskyauction.com data cannot. While a similar caveat is true for other annual release bourbons, we can sometimes determine difference between years using age/maturation and proof. For example, George T. Stagg is released annually but has a different proof and age each year, which allows us to separate the different vintages.¹⁹ Ultimately, however, because of such differences, we cannot easily combine the two data sets and in our repeat sales framework, which we explain in detail in the next subsection, the difference in granularity means that our whiskyauction.com data is a little more lenient regarding what counts as a repeat sale for a handful of bourbons. That is, our auction data

¹⁹A bourbon’s age is the years of maturation of the youngest barrel that contributed to the bottle. All bottles of bourbon, except for aptly-named “single barrel” bourbons, are a mix of many dozens (and often hundreds) of barrels to help maintain a consistent taste profile.

occasionally treats products that differ slightly from year to year as perfect substitutes while our SWT data can usually identify even mildly different bottles as unique products.

3.2 Repeat Sales Framework

Our main empirical exercise is to estimate a price index for bourbon as a product category. To do so, we focus on the information contained in “log-price relatives,” where each log-price relative is the difference between the log of consecutive sale prices of the same product, regardless of the time between the sales. The repeat-sales approach relies on the idea that the expected difference in prices for sales of the same product at different times is equal to the change in the price predicted by the overall category price index between those times plus an error term; Bailey et al. (1963) developed this method to estimate real estate price indices.²⁰ Specifically, for sales of good i , prices and indices between t and t' are related as follows:

$$\frac{P_{it'}}{P_{it}} = \frac{B_{t'}}{B_t} U_{itt'}. \quad (1)$$

In (1), P_{it} is the sale price of i in time period $t \in T$. For any two consecutive sales, t is the time of the first sale and t' is the time of the subsequent sale ($t' > t$). The B_t term represents the general price index for that type of good at time t and $U_{itt'}$ is the multiplicative error term for the sale pair and follows a log-normal distribution. Taking the natural logarithm of each side gives

$$r = b_{t'} - b_t + u_{itt'}. \quad (2)$$

In (2), $r = p_{it'} - p_{it}$ and p , b , and u refer to the logarithms of P , B , and U (therefore, $u_{itt'}$ is an independent and identically distributed homoscedastic random error). The empirical analog of the repeat-sales methodology involves an estimating equation of the form

$$r = X\beta + \mu. \quad (3)$$

In (3), r and μ are n -dimensional vectors where n is the number of log-price relatives that can be calculated. A log price relative r for sales that occur in periods t and t' is $r = \log(p_{t'}) - \log(p_t)$.

²⁰Our description of the repeat sales methodology borrows nomenclature and notation from Nagaraja et al. (2014).

The matrix X is $n \times T$ -dimensional where T refers to the number of time periods in which sale prices are observed for any item in the data set. Completing the equation, β is a T -dimensional column vector of logarithms of the price indices to be estimated. There is no constant term in the regression, so that first value of the index is normalized at zero ($\beta_0 = 0$). The β_t coefficients (from $t = 0, \dots, T$) can then be converted into a price index with a base value equal to 1 by taking the inverse log of each coefficient.

In practice, for any bourbon sold in $k \leq T$ time periods we calculate $k - 1$ log price relatives, which approximate the percent increase in price between two given time periods. We regress the log-price relatives on a set of T indicator variables. That is, we create a $T \times 1$ column vector for each time period $t \in T$ and each row of the vector is set to zero except the time of the later sale is set to +1 in the row corresponding to that t 's log price relative. In the same row, we enter a -1 in the vector corresponding to the time period of the prior sale. Because our whiskeyauction.com data provides only the year and month of each sale, we focus on monthly average sale prices by product. That is, each log-price relative is equal to the difference in the log of average sale price between two months where we observe a sale occurring. With this approach, we obtain 6,499 monthly average log price relatives in our whiskeyauction.com data and 1,509 in our SWT data. Appendix A provides more information on the repeat sales method and Table A1 provides an example of the required data structure.

4 Main Findings

We present our main findings in three subsections. First, we determine the rate of return on bourbon implied by our whiskeyauction.com and SWT data by creating a bourbon price index using a repeat sales regression framework. As part of that analysis we compare changes in prices across the two sources. We then examine returns to hedonic characteristics to determine whether each market prices these characteristics similarly. Our hedonic analysis is limited, however, by missing data on many of the bottles in each data set, particularly our auction data. Finally, we use the monthly bourbon price index values to examine bourbon's potential as an alternative investment.

4.1 Bourbon Repeat Sales Price Index

Using the repeat sales regression we describe in Section 3 we obtain the estimates in Table 3 and Figure 2. In Table 3, we present the inverse log of the regression coefficients as monthly index values from April 2011 (2011m4) to October 2019 (2019m10) across multiple columns. By construction, the April 2011 index value is the base value and is set equal to 1. Interpreting the estimates, the 2.43 index value in February 2019 suggests a 143% return in under eight years. The index value for October 2019, at the end of the sample period, is 2.004, implying about a 9.1% annual return over the eight-year sample period. Figure 2, which perhaps better illustrates our estimates, is a plot of the values in Table 3 over time.

Given the estimates in Table 3 and Figure 2 are based on repeat sales, the secondary market appears to be “cooling” off a little toward the end of our sample period. Even with this slight downturn, the rate of return on bourbon over the sample is larger (at least during our sample time period) than the typical rate of return on wine, stamps, violins, or art implied by the analyses of Burton and Jacobsen (2001), Mei and Moses (2002), Dimson and Spaenjers (2011), Graddy and Margolis (2011), and Dimson et al. (2015). Note that the repeat sales regression methodology ensures that the price increases we observe cannot be due only to changes over time in the underlying sample of bourbons used to construct the index.

We present index values developed using our Sweet Water Trading data in Table 4 (and in Figure 3 where we plot the estimated index values over time to aid interpretation). Again, our table of estimates spans several columns. However, we have just over three years of data between late 2014 and late 2017, meaning that the time period is significantly shorter than our auction data. For comparability, we again average sale prices for each product *within* a calendar month. Therefore, each bourbon’s log-price relative is based on differences in the log of the average sale price between two months in which sales are observed.

In Table 4, an estimate of 1.012 (November 2014) implies that bourbon prices increased by 1.2% relative to the base month (October 2014). By November of 2017, the index is 1.743, representing a 74.3% increase in bourbon prices relative to late 2014 (or about 20.4% per year).²¹ Note that

²¹We calculate an approximate annual rate of return using the standard formula $A = P(1 + r)^t$ where A is the final index value, P is the initial index value, r is the unknown annual return and t is the number of years. For example, in our SWT data, the final value is 1.743, the initial value is 1, and $t \approx 3$; plugging these values in we get $1.743 = 1(1 + r)^3$ and solving for r , $r \approx 20.4\%$.

between October 2014 and November 2017, the whiskyauction.com index value increased from 1.559 to 1.993 (implying a 27.8% total increase in prices, or about 9% per year). We present the values of both price indices from October 2014 to November 2017 (the time period that is common to both data sources) in Figure 4a - normalized so that October 2014 is the base month in each series - where we can see larger increases in the SWT market prices during the sample period.

We speculate that the “new” nature of the SWT secondary market in 2014 perhaps contributed to lower initial prices, allowing for a greater increase over time. That is, if there were relatively fewer participants in 2014 it might inhibit efficient price discovery. The price patterns of 2014 George T. Stagg in Figure 1 perhaps support such a narrative. The SWT market price was below \$300 in early 2015 while the whiskyauction.com price was closer to \$400 but prices are more similar in each market by late 2017 (at around \$500). On the other hand, while the SWT data index values in Figure 4a are generally greater than the whiskyauction.com data index values throughout 2015, 2016, and 2017, the indices diverge markedly only at the end of the sample period. From our SWT data summary statistics (Table 2), we see that the frequency of observations declines in 2017, perhaps contributing to the divergence in the index values toward the end of the sample period. Supporting the idea that the SWT market took some time to become efficient, however, price changes are similar across markets if we allow a wider time-frame. For example, the whiskyauction.com index values for August 2014 relative to January of 2018 (1.32, 2.26) imply a 71.2% increase in prices between the two months (a 17.5% annual return). Such data and timing issues suggest that focusing on frequently traded products might see greater concordance between the indices. In Figure 4b, therefore, we present index values from both data sources but limit our sample to the 20 most frequently sold bourbons in our Sweet Water Trading data. Of these 20 products, 19 appear in the whiskyauction.com data but in a handful of cases (Old Rip Van Winkle 2014, Eagle Rare 17 2014, and Pappy Van Winkle of any maturity) we cannot determine exact vintages (i.e., release year) to align the data sources perfectly. Because we limit the sample to only a subset of bourbons we have repeat sales data only from October 2014 to June 2017 in both data sources with 266 repeat sales in the SWT data and 348 in the whiskyauction.com data. In Figure 4b, we see that when we limit the sample to a similar set of products, the index values over time are more aligned.²²

²²Note that products that appear in 2014 data are naturally older, and have perhaps reached a stable secondary market price, limiting price increases over time.

4.2 Hedonic Analysis

We next examine the role of hedonic characteristics in bourbon price determination. We present a summary of the available hedonic characteristics, by year, in Table 5 for our SWT data. We include information on sale price, age (when available), proof ($= 2 \times$ the percentage of alcohol in the bottle), an indicator for barrel proof ($=1$ if no water has been added after maturation), annual release ($=1$ if the product is only released once per year), and review score out of 100 from whiskeyadvocate.com. We continue to focus on “fifth” size bottles but because this analysis is not restricted to repeat sales, our sample is somewhat larger (we now have a 2018 observation, for example). We use the available information on hedonic characteristics to further explore how secondary market prices are determined. The SWT data generally contains information on these hedonic characteristics for a greater proportion of products and, for that reason, we focus mainly on SWT data in this part of our analysis. In particular, we examine an estimating equation of the following form;

$$Price_{it} = \alpha + X_i\beta + \gamma_t + \epsilon_{it}.$$

In the equation, $Price_{it}$ refers to the price of product i at time t , α is a constant, X_i contains some or all (depending on specification) of the hedonic characteristics of interest laid out in Table 5, γ_t is a year fixed effect, and ϵ is an idiosyncratic error term. We present the associated estimates, based upon our SWT data, in Table 6. Specifically, we present six specifications and include year fixed effects in all specifications. The first column presents a parsimonious specification with only these year fixed effects. The coefficients should be viewed as relative to prices in 2014. We see a familiar pattern; prices in 2015, 2016, and 2017 are significantly higher than 2014. (the 2018 estimate is not reliable given there is only one 2018 observation). Compared to the repeat sales regression, the price increases we see in the hedonic analysis are somewhat muted. For instance, the estimates suggest prices in 2017 were at most \$208.74 higher relative to prices in 2014 (when using the largest 2017 indicator coefficient estimate in column five). Given the mean sales price among the full sample was \$307.24 in 2014, a \$208.74 or 67.9% price increase over three years is lower than that predicted by the repeat sales approach (which suggested a 74.3% return over three years). However, such an analysis is not really appropriate because the type of bottle on the market in 2017 was different. For example, Table 5 shows that, relative to 2014, sales in 2017 featured bourbon

that was less mature, had a lower proof, was less likely to be barrel proof, and was less likely to be an annual release. Such changes in composition over time are why the repeat sales method is generally viewed as superior when estimating potential investment returns.

In subsequent columns, we progressively add hedonic characteristics of interest. We have a total of 3,305 observations. For each of these, we know if the bottle is barrel proof and/or if it is a limited once-per-year release. For that reason, we first add the indicator for barrel proof (bottled without dilution, typically at a proof of 120 or above, which amounts to 60% alcohol by volume) in the second column and then add an indicator for annual release in the third column of estimates. Surprisingly, across specifications barrel proof does not seem to be associated with higher prices. It is worth noting here that most of the once-per-year Pappy Van Winkle expressions, consistently some of the most expensive products on the secondary market, are not bottled at barrel proof. Emphasizing the coveted nature of annual release bourbons, we find that the indicator for annual release is associated with large and statistically significant positive effects on prices.

In the fourth column we control for the actual proof of the bottles in question. A bourbon's proof is legally required to be printed on the bottle but we could not determine the proof for about 500 of the bottles in the SWT data. In the fifth column we add the bourbon's age as measured by the number of years spent in maturation in oak containers. There is no legal requirement on how long a bourbon must be allowed to mature, and the bottle must indicate the age only if the bourbon is less than four years old. For this reason, a bourbon's age is not always available; we therefore lose several hundred further observations. In the final column, even though they are available for only a subset of the products in our data, we include review scores from whiskeyadvocate.com.²³

In the estimates, the coefficients associated with age, proof, and review scores are noisy and because data is sometimes missing in these categories, we are hesitant to draw any confident conclusions. On the other hand, the estimates strongly suggest that annual release bourbons are contributing to the price increases seen in the repeat sales regressions while being a barrel proof product seems relatively less important. To check on this finding we return to the repeat sales analysis from earlier but restrict the sample first to only annual release bourbons and then to barrel proof products. Figure 5 contains plots of the coefficient estimates from those repeat sales

²³We did not want to introduce review scores from more than one source because of differences in procedures, timing, and review scores/scales.

regressions. The figure further illustrates the importance of the repeat sales approach: the annual release bourbons increase significantly in price but not by more than barrel proof products (note that there is considerable overlap). Specifically, the index values are 1.78 and 1.80 for the final month of the SWT sample when the sample is restricted to annual release and barrel proof products, respectively.

Last, we present summary statistics and then regression estimates that examine returns to hedonic characteristics in our auction data in Tables 7 and 8. As we mention earlier, we do not have as much product information on each of these bottles relative to the SWT data. However, looking at the returns to various characteristics we again see that the indicator for “barrel proof” has a mixed effect on prices, whereas the continuous measure of proof, the annual release indicator, and maturation/age are generally positively associated with prices. We also include year fixed effects in each regression and report those estimates in the table. Note that we choose 2014 as the omitted year to enable a direct comparison with Table 6. Overall, we see that prices increase considerably after 2014, as in Table 6. In the next subsection, we use our estimated price indices to examine bourbon’s potential as an alternative investment.

4.3 Bourbon’s Investment Potential

Given we observe large price increases over time, we next examine bourbon’s appeal as a viable alternative investment. Pedersen et al. (2014) suggest that portfolio allocations to alternative investments are driven in part by low correlations with publicly traded investments (e.g., stocks, bonds, and so on). Therefore, we first examine simple pairwise correlations of monthly bourbon returns with stocks (as proxied by the Standard and Poor’s Depository Receipt S&P 500 Exchange Traded Fund Trust, abbreviation “SPY”), bonds (Vanguard Total Bond Market Exchange Traded Fund, abbreviation “BND”), commodities (Invesco DB Commodity Index Tracking Fund, abbreviation “DBC”), and, as a measure of inflation, the Consumer Price Index (CPI). We also examine the correlation of bourbon with two common portfolio weightings: a 60/40 mix of stocks and bonds and a 50/30/20 mix of stocks, bonds, and commodities.

We first present correlations between monthly bourbon returns and different investment options (and the CPI) in Table 9. Interestingly, our auction and peer-to-peer bourbon market returns exhibit a mild negative correlation with one another. They are also negatively related to stocks (SPY) and

commodities. In contrast, both exhibit positive correlation with bonds and the CPI. The relationship with typical diversified portfolios is generally negative except for a small positive correlation between returns in our peer-to-peer bourbon sales data and the 60/40 stock/bond portfolio, suggesting that an investor who participated in the auction rather than peer-to-peer markets might experience greater portfolio enhancements.

In Table 10 we present asset returns, volatility, distribution characteristics, and risk-adjusted performance for the assets we examine in Table 9.²⁴ Nominal arithmetic returns in our auction and peer-to-peer data are high relative to other assets/portfolios but geometric returns are lower.²⁵ In isolation, these returns come with greater volatility; auction bourbon returns have a standard deviation of 12.63% while the peer-to-peer data has a standard deviation of 7.94%, each higher than the nearest asset (commodities at 4.5%). Kraus and Litzenberger (1976) indicate that investors prefer risky assets with positive skewness, which bourbon exhibits in our auction data but not the peer-to-peer market data. On the other hand, both bourbon assets also have higher likelihood of fat tail events (i.e., higher excess kurtosis). While the standalone risk-adjusted performance of bourbon in our auction data seems poor relative to other assets (Sharpe ratio = 0.12), our peer-to-peer bourbon returns exhibit a higher Sharpe ratio at 0.21.²⁶ We caution that this finding may be driven by a smaller sample size and return smoothing from less frequent pricing (for a similar example in the real estate asset class, see Geltner, 1991).

Notably, when we examine a 5% addition of bourbon to traditional portfolios, bourbon’s ability to enhance portfolio returns becomes apparent. A 60/40 stock/bond portfolio with bourbon has higher returns, lower volatility, and exhibits positive return skewness. Focusing on nominal returns, the Sharpe ratio of the 60/40 portfolio improves from 0.33 to 0.37 (0.41) if we include auction (peer-to-peer) monthly bourbon returns. We find similar improvements from the addition of bourbon to a 50/30/20 stock/bond/commodity portfolio. Standalone real returns (i.e., returns adjusted for monthly changes in the Consumer Price Index) are generally similar. Indeed, the high correlation of auction bourbon returns with inflation, positive standalone returns, and positive return skewness

²⁴In Table B1 we present summary statistics for annual returns.

²⁵Arithmetic returns are a simple average return where we sum the series of returns and then divide by the number of returns. Geometric returns are calculated by multiplying all n returns, taking the n -th root and subtracting the initial capital.

²⁶The Sharpe ratio for asset m is $r_m - r_f / \sigma_m$ where r_m is the asset’s average return in a specific time period, r_f is the risk-free rate of return during that time period, and σ_m is the standard deviation of asset m ’s returns. A Sharpe ratio therefore calculates an asset’s average return in excess of the risk-free rate per unit of volatility.

make the asset class a valuable inflation hedge relative to commodities (although commodities have higher correlation with inflation). We again find higher Sharpe ratios in traditional portfolios when real bourbon returns are added.

Pedersen, Page, and He (2014) also find that returns for alternative assets including private equity, real estate, farmland, and timberland “have significant exposure to the same risk factors” that drive traditional asset volatility. To examine this possibility for bourbon, we present estimates from various factor models in Table 11. These model specifications include a basic market model, a three-factor Fama-French model (= the market model plus the “small-minus-big” factor, which accounts for the excess return that smaller market capitalization companies return versus larger companies, and the high-minus-low book-to-market factor, referring to the excess returns for high book value-to-market firms; see Fama and French, 1993), a four-factor model including momentum (momentum refers to returns from a strategy of buying past winners and selling past losers; see Carhart, 1997), and a five-factor model including a liquidity factor (which accounts for excess risk and returns for those equities that are less frequently traded than others in the market; see Pástor and Stambaugh, 2003). Accounting for these last two factors is particularly important because we observe significant auto-correlation (-0.31 for auction returns and -0.18 for peer-to-peer returns) in bourbon returns and bourbon markets are less liquid than traditional asset classes. For the three-factor model, the estimating equation is of the following type:

$$R_{it} - R_{ft} = \alpha_{it} + \beta_1(R_{mt} - R_{ft}) + \beta_2SMB_t + \beta_3HML_t + \epsilon_{it}.$$

In the model, R_{it} is the total return of asset i at time t (in our case, i =bourbon), R_{ft} is the risk free rate (as proxied by one-month Treasury Bill returns), $R_{mt} - R_{ft}$ represents the difference between the market portfolio return and the risk free rate at time t , SMB_t is the size premium (returns from small market capitalization firms relative to big firms), HML_t is the value (high minus low) premium, and ϵ_{it} is an independent and identically distributed error term. Relative to the three-factor model, the basic market model eliminates SMB_t and HML_t , whereas four and five factor models add measures of momentum and liquidity, respectively.

The estimates in Table 11 show that bourbon returns exhibit negative sensitivity to the market factor, particularly in our bourbon auction data. Bourbon returns appear to have the highest

sensitivity to the momentum factor though the direction reverses when examining returns in the peer-to-peer market data. In each specification, the monthly return estimates (alphas) are economically large (1.72% to 2.35% monthly) and are statistically significant in most specifications at the 10% level or better. We want to specifically note, however, that these estimates should be viewed with caution as the sample size is relatively small (e.g., we have only 37 monthly observations in the case of our peer-to-peer/decentralized data).

Overall, it appears that bourbon returns have low correlation with major asset classes (stocks, bonds, and commodities) and bourbon appears to provide better inflation protection, enhances the risk-adjusted returns of traditional portfolios, and generates economically significant alpha (investment returns) across a variety of factor models. As an asset class, while bourbon may not be sufficiently scalable for the needs of large institutional investors, our findings suggest that bourbon can be an effective alternative investment in modestly sized portfolios.

5 Discussion and Conclusion

Using two complementary sources of data, we find that secondary markets for bourbon appear to work quite well. These are generally active markets with lots of buyers and sellers. Therefore, it is perhaps not surprising that we find similar price increases (of 17% to 20% or more per year) and similar returns to product characteristics over recent years in geographically separate and institutionally-different markets. Our analysis is limited, however, by a short sample and, in some cases, by unknown and/or unavailable product details.²⁷ When studying bourbon’s investment performance, we find that bourbon returns have low correlation with stocks, bonds, and commodities, provide solid inflation protection, and appear to enhance the risk-adjusted returns of traditional portfolios. Our estimates therefore suggest that bourbon can be an effective alternative investment, at least in smaller portfolios.

Realizing any such gains, however, might be legally troublesome. On the other hand, the prevalence of online auction sites and peer-to-peer sales groups suggests that law enforcement agencies are not particularly concerned about high-end bourbon sales. Moreover, there are movements

²⁷Some product details are unknown because our data is incomplete and/or the information we have does not allow us to determine the exact product. In other cases, information is missing because it is simply not available at all from the distiller/producer.

underway to legalize the sale of vintage and rare bottles. One example is a recent revision to Kentucky's alcoholic beverage statute that allows licensed retailers to purchase rare and vintage distilled spirits from individuals who are unlicensed.²⁸ Sales facilitated by licensed auction houses will also become more attractive if prices continue to increase. It remains to be seen what effect any such changes will have on the secondary markets we study here.

Note that we provide no specific investment advice. Instead, our goal is to describe what is happening in the market for bourbon in recent years. The recent bourbon boom could easily be the next "Beanie Baby" phenomenon: here today and gone tomorrow. For example, distillers might increase production enough to clear the market at retail prices, substitutes (rye whiskey, scotch, and so on) may become more attractive options, or regulators could begin to crack down on secondary market sales. That might be a welcome turn of events to many who bemoan that their favorite whiskey is missing from their local liquor store's shelves.

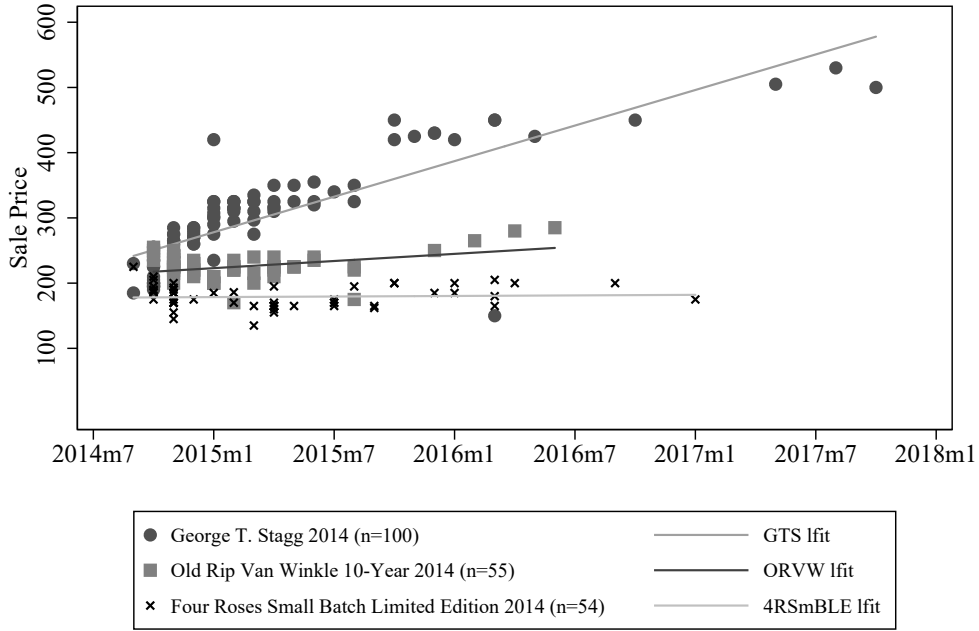
²⁸See <https://www.go-wine.com/wine-article-1047-The-Bourbon-Secondary-Market-Is-Now-Legal-in-Kentucky-Sort-of.html>.

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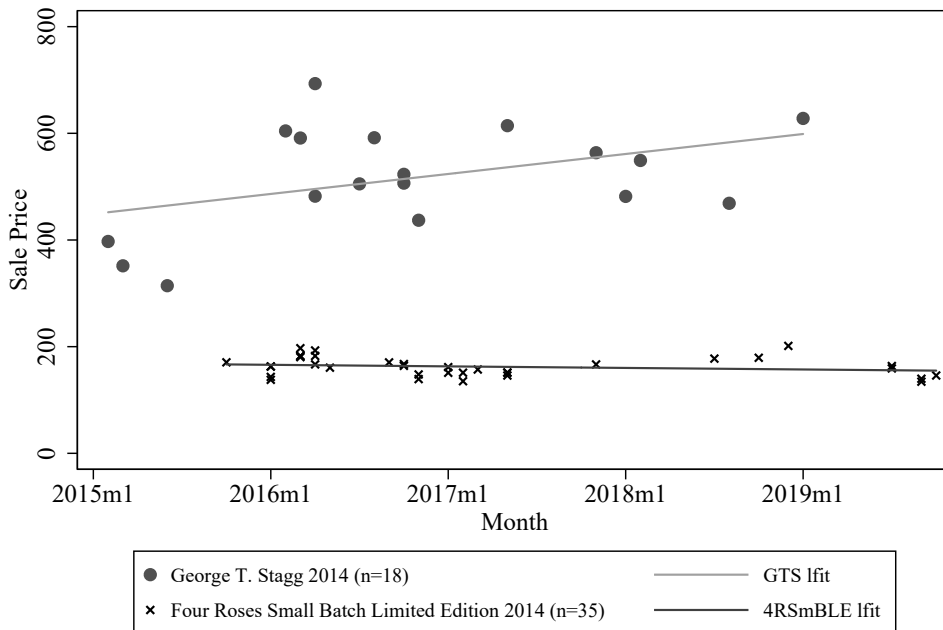
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Figure 1: Observed Sale Prices Over Time, Selected Bourbons



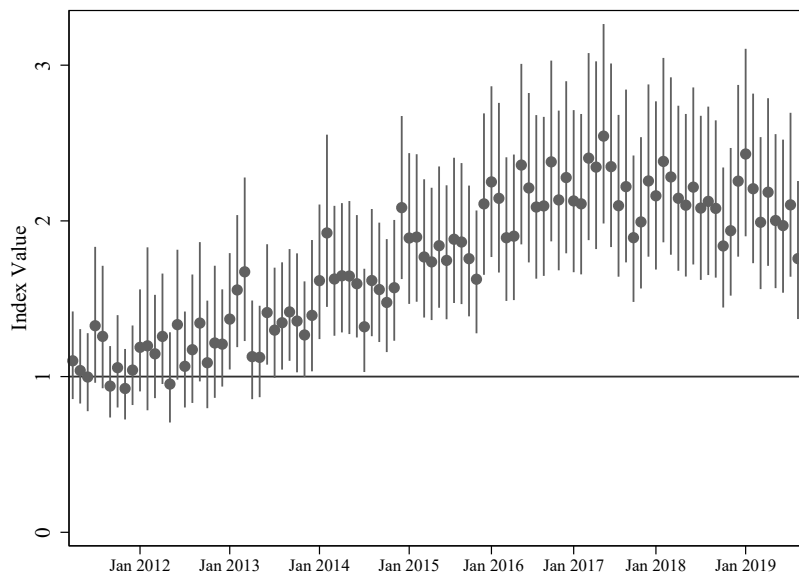
(a) 2014-2017 Sweet Water Trading Data



(b) 2015-2019 whiskyauction.com Data

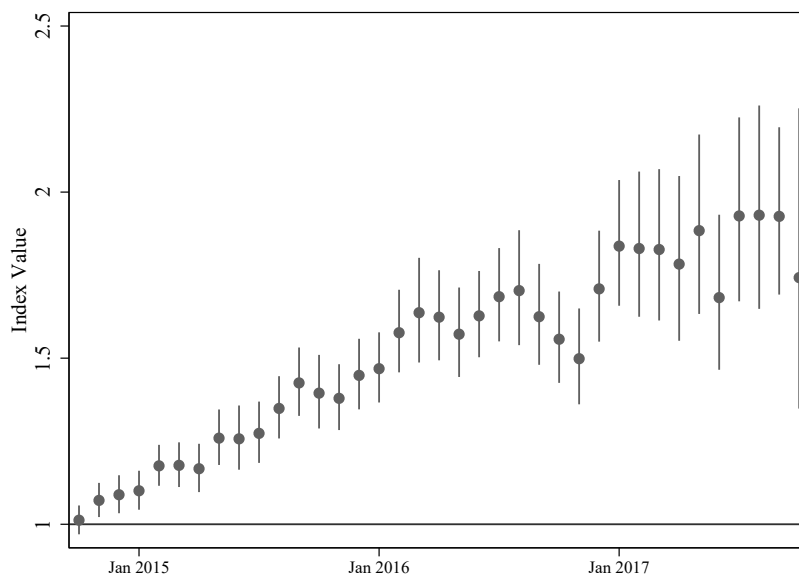
Data Source: Strong Water Trading Sales Records 2014 to 2017 and whiskyauction.com Sales Records from 2011 to 2019. GTS = George T. Stagg, 4RSmBLE = Four Roses Small Batch Limited Edition, ORVW = Old Rip Van Winkle, lfit = Regression Fit.

Figure 2: Monthly Price Index - Whiskyauction.com Data April 2011 to October 2019



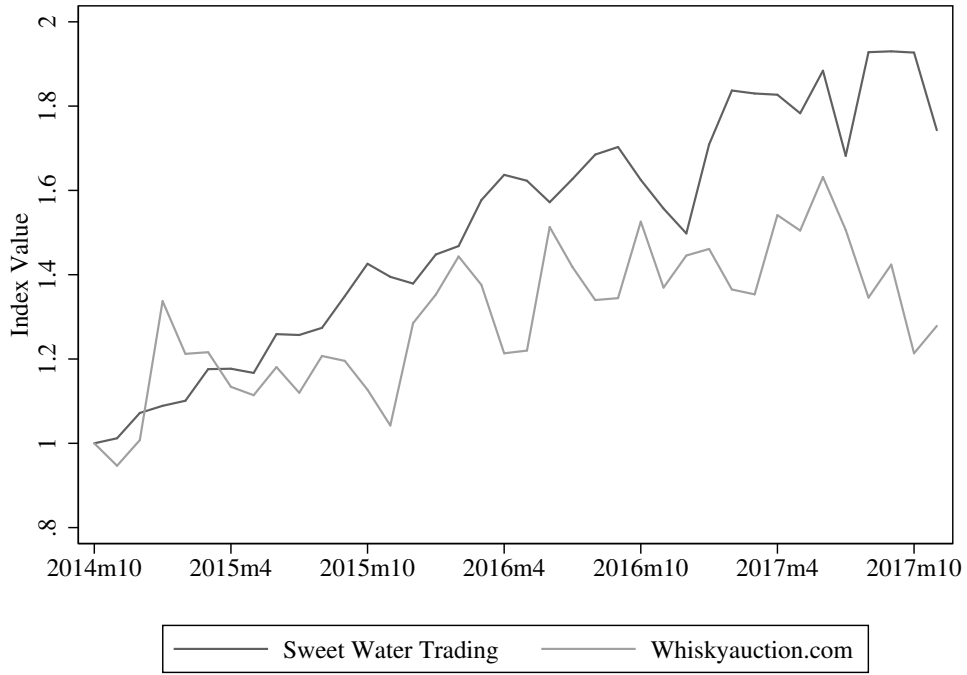
Data Source: Estimates are based on www.whiskyauction.com from April 2011 to October 2019.

Figure 3: Monthly Price Index (SWT Data - Oct 2014 to Nov 2017)

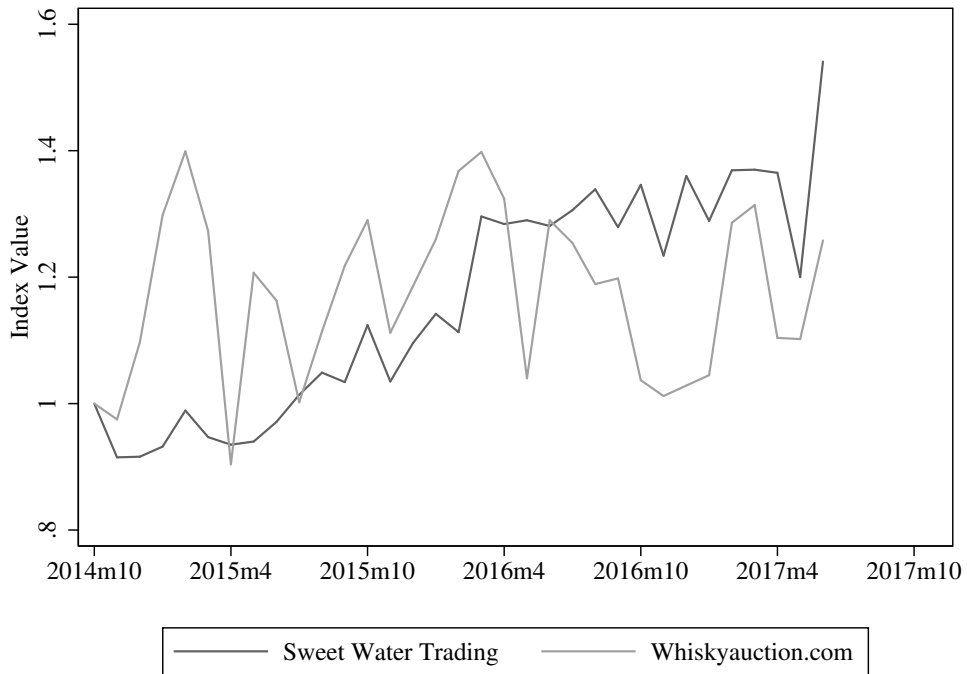


Data Source: Strong Water Trading Sales Records 2014-2017

Figure 4: Monthly Price Index Comparison - Oct 2014 to Nov 2017



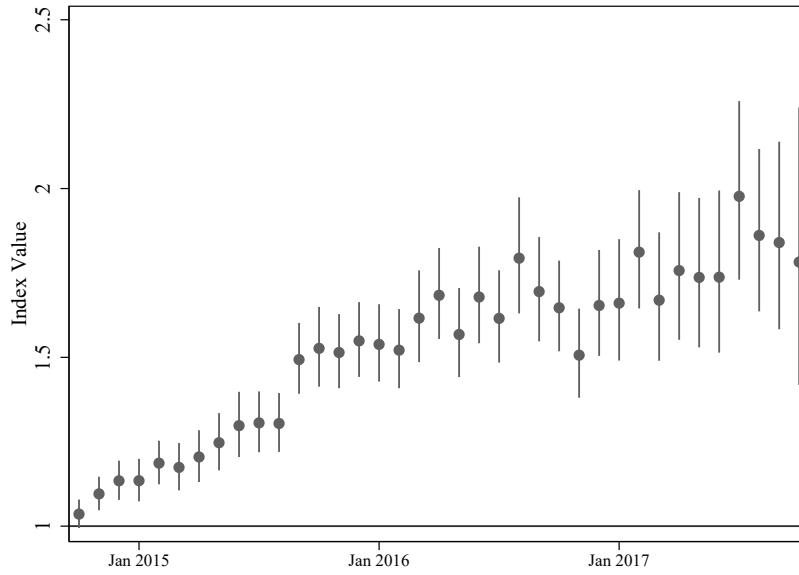
(a) 2014-2017 Complete Sweet Water Trading and Whiskeyauction.com Data



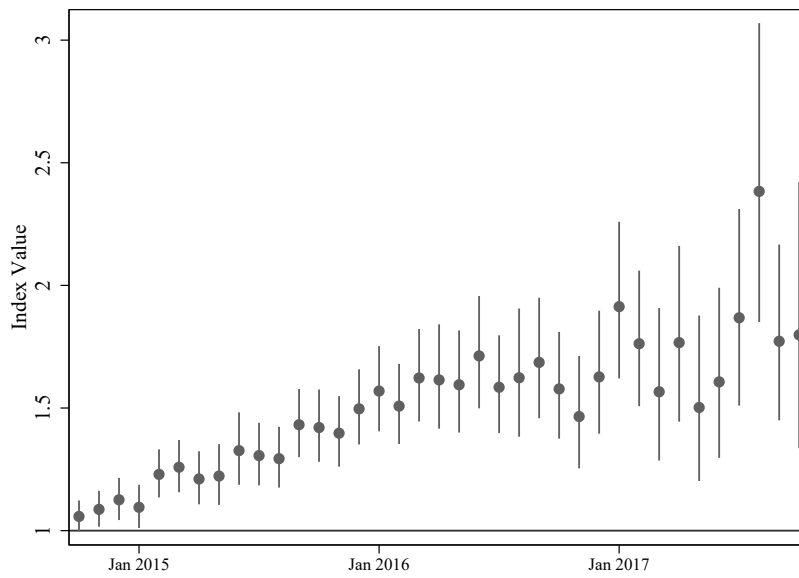
(b) 2014-2017 “Top 20” Sweet Water Trading and Whiskeyauction.com Data

Data Source: Strong Water Trading Sales Records 2014 to 2017 and whiskeyauction.com data from 2011 to 2019 limited to the 20 bourbons appearing most frequently in the Strong Water Trading data, all but one of which (namely 2013 Four Roses Small Batch Limited Edition) also appear in the whiskeyauction.com data.

Figure 5: Monthly Price Index - SWT Data 2014 to 2017)



(a) Annual Releases Only



(b) Barrel Proof Products Only

Data Source: Strong Water Trading Sales Records 2014-2017

Table 1: Summary Statistics for *whiskyauction.com* Data 2011 to 2019

		2011	2012	2013	2014	2015	2016	2017	2018	2019
Price	Mean	\$ 60.53	\$ 97.50	\$ 148.71	\$ 291.46	\$ 283.21	\$ 304.08	\$ 294.77	\$ 293.08	\$ 202.85
	Std. Dev.	(52.06)	(117.68)	(217.38)	(338.70)	(369.67)	(481.85)	(457.65)	(539.72)	(350.17)
	Median	\$ 42.03	\$ 54.07	\$ 66.46	\$ 165.10	\$ 144.44	\$ 130.27	\$ 145.55	\$ 142.48	\$ 92.63
	Min	\$ 9.99	\$ 11.29	\$ 6.60	\$ 9.52	\$ 7.51	\$ 7.79	\$ 10.38	\$ 5.68	\$ 5.51
	Max	\$ 360.17	\$ 926.83	\$ 2,015.74	\$ 2,438.65	\$ 2,868.75	\$ 5,224.83	\$ 6,386.32	\$ 13,797.09	\$ 5,039.74
Whiskey Age (Years of Maturation)	Mean	8.8	10.4	10.6	12.4	11.6	10.8	10.6	10.9	9.7
	Std. Dev.	(4.00)	(4.72)	(4.62)	(5.21)	(5.15)	(4.58)	(4.44)	(4.30)	(4.36)
	Median	8	10	10	12	12	10	10	10	9
	Min	3	4	3	3	3	3	3	3	2
	Max	20	23	23	28	27	28	28	27	28
Proof (Alcohol by Volume $\times 2$)	Mean	89.84	92.52	94.01	97.83	96.94	96.68	96.2	97.56	92.93
	Std. Dev.	(12.93)	(14.34)	(14.82)	(15.56)	(15.34)	(15.14)	(14.89)	(15.57)	(13.15)
	Median	86	88.3	90	93	90.2	90.4	90.4	93	90
	Min	80	80	80	80	80	74	80	80	74
	Max	143	144.8	144.8	144.8	172	150	160	172	172
Sales per Year	Mean	3.56	3.65	4.76	7.81	8.27	11.17	12.78	11.03	9.53
	Std. Dev.	(2.48)	(2.95)	(4.05)	(9.41)	(8.10)	(11.44)	(16.78)	(19.24)	(16.67)
	Median	3	3	3	4	5	7	6	4	4
	Min	1	1	1	1	1	1	1	1	1
	Max	11	12	17	40	33	43	66	87	82
	Observations	302	256	540	886	1,322	1,631	1,598	1,647	1,891
	N	138	128	219	329	443	480	494	604	672

Source: Products with repeat sales from 2011 to 2019 from www.whiskyauction.com. All values converted to nominal dollars in the year of sale using euro-dollar exchange rates in the actual month of sale provided by the U.S. Federal Reserve (see <https://fred.stlouisfed.org/tags/series?t=exchange+rate%3Bmonthly>). Notice that, taking 2015 as an example, the observation and N numbers refer to a total of 1,322 records for 443 unique products. Neither number refers to pairs of repeat sales.

Table 2: Summary Statistics for *Strong Water Trading* Data 2014 to 2017

		2014	2015	2016	2017
Price	Mean	\$ 307	\$ 381	\$ 508	\$ 487
	Std. Dev.	(278)	(364)	(448)	(460)
	Median	\$ 225	\$ 270	\$ 375	\$ 335
	Min	\$ 25	\$ 25	\$ 32.5	\$ 32.5
	Max	\$ 2,350	\$ 4,100	\$ 3,100	\$ 2,500
Whiskey Age (Years of Maturation)	Mean	14	14	14	13
	Std. Dev.	(4)	(5)	(4)	(5)
	Median	12	12	12	12
	Min	2	2	4	4
	Max	28	28	28	27
Proof (Alcohol by Volume $\times 2$)	Mean	107	107	107	105
	Std. Dev.	(17)	(17)	(17)	(15)
	Median	101	101	100	101
	Min	80	80	80	80
	Max	145	145	145	144
Sales per Year	Mean	11	10	4	2
	Std. Dev.	(12)	(10)	(3)	(2)
	Median	7	6	3	2
	Min	1	1	1	1
	Max	50	42	14	8
Observations		995	1,372	560	195
N		265	347	237	118

Source: 2014 to 2017 Strong Water Trading Secondary Market Repeat Sales. The spreadsheet of sales records is publicly available at https://docs.google.com/spreadsheets/d/1CAh7R1_si750ruEVNubV3Pghf78HcfbOqNhGjLP_lc/htmlview (link last accessed 11/1/2019). Notice that, using 2015 as an example, the observation and N numbers refer to a total of 1,372 records for 347 unique products. Neither number refers to pairs of repeat sales.

Table 3: Bourbon Price Index Based on Repeat Sales Regressions - Whiskyauction.com Data 2011 to 2019)

Month	Index Value	Month	Index Value	Month	Index Value	Month	Index Value
2011m4	1						
	-						
2011m5	1.102 (0.142)	2013m6	1.124 (0.148)	2015m7	1.746 (0.217)	2017m10	1.892 (0.237)
2011m6	1.039 (0.121)	2013m7	1.411 (0.195)	2015m8	1.882 (0.236)	2017m11	1.993 (0.245)
2011m7	0.997 (0.126)	2013m8	1.298 (0.178)	2015m9	1.864 (0.229)	2018m1	2.256 (0.279)
2011m8	1.327 (0.219)	2013m9	1.346 (0.174)	2015m10	1.757 (0.212)	2018m2	2.161 (0.273)
2011m9	1.258 (0.197)	2013m10	1.415 (0.181)	2015m11	1.625 (0.199)	2018m3	2.382 (0.299)
2011m10	0.939 (0.116)	2013m11	1.357 (0.192)	2016m1	2.109 (0.262)	2018m4	2.282 (0.288)
2011m11	1.057 (0.149)	2013m12	1.267 (0.155)	2016m2	2.250 (0.277)	2018m5	2.145 (0.268)
2011m12	0.924 (0.114)	2014m1	1.393 (0.212)	2016m3	2.145 (0.275)	2018m6	2.101 (0.264)
2012m1	1.042 (0.129)	2014m2	1.616 (0.218)	2016m4	1.892 (0.233)	2018m7	2.217 (0.287)
2012m2	1.188 (0.165)	2014m3	1.923 (0.278)	2016m5	1.902 (0.236)	2018m8	2.082 (0.266)
2012m3	1.198 (0.259)	2014m4	1.627 (0.211)	2016m6	2.359 (0.293)	2018m9	2.125 (0.273)
2012m4	1.146 (0.167)	2014m5	1.647 (0.210)	2016m7	2.211 (0.275)	2018m10	2.080 (0.255)
2012m5	1.258 (0.179)	2014m6	1.646 (0.216)	2016m8	2.089 (0.265)	2018m11	1.839 (0.227)
2012m6	0.952 (0.146)	2014m7	1.597 (0.199)	2016m9	2.096 (0.258)	2018m12	1.937 (0.240)
2012m7	1.334 (0.209)	2014m8	1.320 (0.167)	2016m10	2.379 (0.293)	2019m1	2.255 (0.279)
2012m8	1.066 (0.155)	2014m9	1.617 (0.206)	2016m11	2.135 (0.259)	2019m2	2.430 (0.304)
2012m9	1.173 (0.206)	2014m10	1.559 (0.194)	2017m1	2.278 (0.279)	2019m3	2.207 (0.275)
2012m10	1.344 (0.224)	2014m11	1.476 (0.183)	2017m2	2.128 (0.263)	2019m4	1.991 (0.247)
2012m11	1.089 (0.173)	2014m12	1.571 (0.196)	2017m3	2.110 (0.260)	2019m5	2.184 (0.272)
2012m12	1.216 (0.212)	2015m1	2.085 (0.264)	2017m4	2.403 (0.303)	2019m6	2.002 (0.250)
2013m1	1.208 (0.158)	2015m2	1.890 (0.244)	2017m5	2.346 (0.304)	2019m7	1.970 (0.248)
2013m2	1.369 (0.188)	2015m3	1.896 (0.239)	2017m6	2.544 (0.323)	2019m8	2.103 (0.266)
2013m3	1.556 (0.214)	2015m4	1.768 (0.224)	2017m7	2.348 (0.298)	2019m9	1.758 (0.224)
2013m4	1.673 (0.264)	2015m5	1.737 (0.215)	2017m8	2.098 (0.262)	2019m10	2.004 (0.258)
2013m5	1.128 (0.160)	2015m6	1.841 (0.229)	2017m9	2.220 (0.280)		
Repeat Sales				6,499			

Source: Estimates rely on www.whiskyauction.com data from early 2011 to late 2019. Note that 2015m3 refers to March of 2015, and so on. April 2011 is the base value (=1). Note that some months are missing because the site operator appears to have taken vacation around the holiday season in 2015, 2016, and 2017.

Table 4: Bourbon Index Based on Repeat Sales Regressions - SWT Data 2014 to 2017

Month	Index	Month	Index	Month	Index	Month	Index
2014m10	1						
	-						
2014m11	1.012 (0.0221)	2015m9	1.349 (0.0478)	2016m7	1.627 (0.0661)	2017m5	1.783 (0.126)
2014m12	1.072 (0.0262)	2015m10	1.426 (0.0524)	2016m8	1.685 (0.0715)	2017m6	1.884 (0.137)
2015m1	1.089 (0.0291)	2015m11	1.395 (0.0564)	2016m9	1.703 (0.0881)	2017m7	1.682 (0.119)
2015m2	1.101 (0.0299)	2015m12	1.379 (0.0505)	2016m10	1.625 (0.0773)	2017m8	1.928 (0.141)
2015m3	1.176 (0.0314)	2016m1	1.448 (0.0541)	2016m11	1.557 (0.0700)	2017m9	1.930 (0.155)
2015m4	1.177 (0.0343)	2016m2	1.468 (0.0538)	2016m12	1.498 (0.0734)	2017m10	1.927 (0.128)
2015m5	1.167 (0.0370)	2016m3	1.577 (0.0633)	2017m1	1.709 (0.0850)	2017m11	1.743 (0.228)
2015m6	1.259 (0.0425)	2016m4	1.637 (0.0802)	2017m2	1.837 (0.0963)		
2015m7	1.257 (0.0492)	2016m5	1.623 (0.0690)	2017m3	1.830 (0.111)		
2015m8	1.274 (0.0470)	2016m6	1.572 (0.0686)	2017m4	1.827 (0.116)		
Observations				1,509			

Standard errors in parentheses. Note: 2014m11 refers to November of 2014, and so on. October 2014 is the base month (index value=1). These estimates use data from Strong Water Trading. The spreadsheet of sales records is publicly available at https://docs.google.com/spreadsheets/d/1CAh7Rl_si750ruEVNbubV3Pghf78HcfbOqNhGjLP_lc/htmlview (link last accessed 11/1/2019).

Table 5: Summary Hedonic Characteristics for SWT Bourbons 2014 to 2018

	2014	2015	2016	2017	2018
Price (\$)	307.24 (279.88)	384.80 (376.97)	521.12 (503.83)	460.18 (446.37)	900.00 (.)
Years of Maturation (Age)	13.67 (4.33)	13.53 (4.68)	13.62 (4.46)	13.25 (4.51)	20.00 (.)
Proof	106.29 (16.71)	106.27 (16.54)	106.37 (17.11)	104.61 (14.90)	90.40 (.)
Barrel Proof (Proportion)	0.31	0.29	0.30	0.26	0.00
Annual Release (Proportion)	0.50	0.44	0.50	0.43	1.00
Review Score (out of 100)	93.19 (3.17)	92.87 (3.29)	92.37 (3.78)	92.10 (4.18)	. (.)
Observations	1,039	1,436	603	226	1

Source: 2014 to 2018 sales records maintained by the “Strong Water Trading” (SWT) bourbon aficionado social network group. Standard deviation in parentheses where appropriate. Notice that we have a 2018 observation here, but it is not a “repeat sale” and therefore does not appear in our earlier analysis.

Table 6: Hedonic Price Analysis - SWT Data 2014 to 2018

	Dep. Var = Price					
	(1)	(2)	(3)	(4)	(5)	(6)
Year=2015	77.56*** (16.93)	76.93*** (17.00)	85.17*** (16.85)	96.42*** (18.63)	99.74*** (18.55)	88.86*** (20.70)
Year=2016	213.88*** (31.64)	213.56*** (31.53)	212.24*** (31.84)	216.07*** (34.65)	213.80*** (34.77)	236.09*** (52.91)
Year=2017	152.94*** (40.77)	151.33*** (40.92)	160.60*** (38.83)	174.01*** (43.02)	208.74*** (39.45)	83.91* (49.63)
Year=2018	592.76*** (23.06)	581.84*** (28.67)	473.29*** (49.22)	495.69*** (52.02)	274.97*** (64.51)	
Barrel Proof Indicator		-35.69 (35.92)	-96.96** (43.11)	-162.25** (68.96)	-124.87** (48.72)	-440.79*** (158.37)
Annual Release Indicator			178.39*** (45.74)	168.33*** (49.36)	139.66*** (47.04)	211.37* (113.10)
Proof				2.36 (1.61)	3.01 (1.82)	4.21** (2.02)
Years of Maturation (Age)					39.61*** (6.71)	3.90 (12.48)
Whiskeyadvocate.com Score (out of 100)						3.37 (10.06)
Observations	3,305	3,305	3,305	2,838	2,521	716

Source: sales records maintained by the "Strong Water Trading" bourbon aficionado social network. Standard errors in parentheses, clustered at the product level (***) $p < 0.01$, * $p < 0.05$, * $p < 0.1$.

Table 7: Summary Hedonic Characteristics for Whiskyauction Bourbons by Year

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Price (\$)	60.53 (52.06)	97.50 (117.68)	148.71 (217.38)	291.46 (338.70)	283.21 (369.67)	304.08 (481.85)	294.77 (457.65)	293.08 (539.72)	202.85 (350.17)
Years of Maturation (Age)	8.80 (4.00)	10.44 (4.72)	10.61 (4.62)	12.35 (5.21)	11.60 (5.15)	10.81 (4.58)	10.63 (4.44)	10.85 (4.30)	9.70 (4.36)
Proof	89.84 (12.93)	92.52 (14.34)	94.01 (14.82)	97.83 (15.56)	96.94 (15.34)	96.68 (15.14)	96.20 (14.89)	97.56 (15.57)	92.93 (13.15)
Barrel Proof (Proportion)	0.06	0.11	0.08	0.14	0.14	0.14	0.13	0.15	0.09
Annual Release (Proportion)	0.06	0.08	0.16	0.21	0.12	0.14	0.12	0.08	0.06
Observations	302	256	540	886	1,322	1,631	1,598	1,647	1,891

Source: 2011 to 2019 Bourbon sales from www.whiskyauction.com. Standard deviation in parentheses where appropriate.

Table 8: Hedonic Price Analysis - 2011 to 2019 whiskyauction.com Data

	Dep. Var = Price				
	(1)	(2)	(3)	(4)	(5)
Year=2011	-230.92*** (40.62)	-221.14*** (42.71)	-170.85*** (22.46)	-146.39*** (25.64)	-89.09*** (29.29)
Year=2012	-193.95*** (40.24)	-189.53*** (41.70)	-145.08*** (23.12)	-127.71*** (25.43)	-117.25*** (29.55)
Year=2013	-142.75*** (41.32)	-135.74*** (42.98)	-122.83*** (26.59)	-114.25*** (29.55)	-64.24*** (21.54)
Year=2015	-8.24 (25.77)	-8.02 (26.12)	23.64 (16.37)	25.47 (16.35)	44.08** (21.81)
Year=2016	12.62 (29.59)	13.53 (29.66)	37.64* (22.12)	40.11* (23.54)	127.69*** (29.62)
Year=2017	3.31 (31.43)	5.44 (32.02)	38.38* (22.03)	41.14* (23.37)	107.71*** (27.97)
Year=2018	1.62 (34.05)	0.99 (34.51)	48.61** (22.35)	46.18** (22.91)	109.18*** (29.88)
Year=2019	-88.61** (35.73)	-82.37** (37.00)	-32.64 (19.86)	-20.35 (21.94)	72.53*** (21.80)
Barrel Proof		116.76*** (42.23)	33.57 (47.36)	-157.51** (64.17)	-22.70 (100.30)
Annual Release Indicator			375.47*** (92.23)	324.82*** (102.81)	100.47 (65.78)
Proof				5.87*** (1.51)	0.93 (2.53)
Years of Maturation (Age)					49.28*** (6.57)
Observations	10,073	10,073	10,073	10,045	6,357

Source: sales records from whiskyauction.com 2011 to 2019. Standard errors in parentheses, clustered at the product level (** p<0.01, * p<0.05, * p<0.1),.

Table 9: Investment Performance: Correlations Among Assets and the CPI

	Bourbon (PtoP)	Stocks	Bonds	Commodities	CPI	60/40	50/30/20
Bourbon (Auction)	-0.020	-0.243	0.320	-0.070	0.107	-0.189	-0.174
Bourbon (Peer-to-Peer / PtoP)		-0.043	0.210	-0.118	0.268	0.003	-0.061
Stocks (SPY)			-0.121	0.508	0.094	0.985	0.941
Bonds (BND)				-0.129	-0.064	0.053	-0.022
Commodities (DBC)					0.303	0.489	0.751
Consumer Price Index (CPI)						0.084	0.179
60/40 Stocks (SPY) /Bonds (BND)							0.943

Notes: Bourbon returns estimated from whiskyauction.com data from 2011 to 2019 and from Sweet Water Trading data from 2014 to 2017. CPI from the Bureau of Labor Statistics. SPY = Standard and Poor's Depository Receipt S&P 500 Exchange Traded Funds Trust, BND = Vanguard Total Bond Market Exchange Traded Funds, DBC = Invesco DB Commodity Index Tracking Fund.

Table 10: Investment Performance: Portfolio Returns (Monthly)

	Mean returns per month		Dispersion of monthly returns			Higher moments		Sharpe Ratio
	Geometric	Arithmetic	Std. Dev.	Min	Max	Skewness	Kurtosis	
<i>Nominal Returns</i>								
Bourbon (Auction) N=102	0.68%	1.46%	12.63%	-32.58%	40.13%	0.37	0.80	0.12
Bourbon (Peer-to-peer) N=37	1.51%	1.65%	7.94%	-30.90%	14.63%	-1.73	5.88	0.21
Stocks (SPY)	0.93%	1.00%	3.62%	-9.71%	11.96%	-0.25	1.02	0.27
Bonds (BND)	0.28%	0.28%	0.95%	-2.58%	3.08%	0.12	0.79	0.30
Commodities (DBC)	-0.70%	-0.60%	4.50%	-14.62%	9.71%	-0.50	0.51	-0.13
Inflation (CPI)	0.13%	0.13%	0.29%	-0.57%	0.82%	-0.11	-0.38	0.45
60/40 Stocks Bonds	0.69%	0.71%	2.16%	-5.17%	7.22%	-0.13	0.94	0.33
with 5% Bourbon (Auction)	0.73%	0.75%	2.05%	-4.71%	6.70%	-0.06	0.89	0.37
with 5% Bourbon (Peer-to-peer)	0.68%	0.69%	1.69%	-3.50%	5.12%	0.28	1.25	0.41
50/30/20 Stocks/Bonds/Commodities	0.43%	0.46%	2.37%	-6.75%	7.54%	-0.19	1.11	0.19
with 5% Bourbon (Auction)	0.43%	0.46%	2.26%	-6.38%	7.21%	-0.20	1.14	0.20
with 5% Bourbon (Peer-to-peer)	0.43%	0.44%	1.82%	-2.95%	4.57%	0.25	-0.13	0.24
<i>Real Returns</i>								
Bourbon (Auction) N=102	0.55%	1.32%	12.60%	-32.75%	40.29%	0.39	0.86	0.11
Bourbon (Peer-to-peer) N=37	1.41%	1.54%	4.85%	-30.66%	14.33%	-2.63	18.09	0.32
Stocks	0.80%	0.86%	3.61%	-9.39%	12.16%	-0.20	1.05	0.24
Bonds	0.14%	0.15%	1.01%	-2.42%	3.55%	0.21	0.82	0.15
Commodities	-0.83%	-0.73%	4.42%	-14.77%	9.23%	-0.48	0.55	-0.17
60/40 Stocks Bonds	0.55%	0.58%	2.34%	-4.86%	7.42%	-0.04	1.00	0.27
with 5% Bourbon (Auction)	0.60%	0.62%	2.03%	-4.79%	6.51%	0.01	0.90	0.30
with 5% Bourbon (Peer-to-peer)	0.58%	0.59%	1.66%	-3.36%	5.17%	0.31	1.26	0.36
50/30/20 Stocks/Bonds/Commodities	0.30%	0.33%	2.34%	-6.90%	7.75%	-0.13	1.32	0.14
with 5% Bourbon (Auction)	0.30%	0.32%	2.22%	-6.54%	7.42%	-0.13	1.35	0.15
with 5% Bourbon (Peer-to-peer)	0.33%	0.34%	1.71%	-2.80%	4.42%	0.25	0.04	0.20

Notes: Bourbon returns estimated from whiskyauktion.com data from 2011 to 2019 and from Sweet Water Trading data from 2014 to 2017. CPI from the Bureau of Labor Statistics. SPY = Standard and Poor's Depository Receipt S&P 500 Exchange Traded Funds Trust, BND = Vanguard Total Bond Market Exchange Traded Funds, DBC = Invesco DB Commodity Index Tracking Fund.

Table 11: Investment Performance: Factor Models

	Bourbon (Auction)				Bourbon (Peer-to-Peer)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Alpha (% Monthly Return)	2.346 (1.255)	2.183 (1.289)	2.057 (1.305)	2.071 (1.315)	1.721 (0.933)	1.721 (0.947)	1.947 (0.965)	1.949 (0.980)
Market minus Risk Free Rate (Mkt-RF)	-0.930 (0.341)	-0.876 (0.369)	-0.793 (0.388)	-0.795 (0.390)	-0.076 (0.304)	-0.114 (0.314)	-0.272 (0.343)	-0.271 (0.349)
Small-Minus-Big Factor (SMB)		-0.162 (0.585)	-0.160 (0.586)	-0.163 (0.590)		0.228 (0.409)	0.209 (0.408)	0.217 (0.418)
High-Minus-Low Factor (HML)		-0.420 (0.540)	-0.208 (0.621)	-0.198 (0.628)		-0.374 (0.364)	-0.598 (0.414)	-0.595 (0.421)
Momentum Factor (MOM)			0.317 (0.455)	0.316 (0.457)			-0.347 (0.311)	-0.341 (0.318)
Liquidity Factor (LIQ)				0.044 (0.286)				0.034 (0.214)
N (Monthly Returns)	102	102	102	102	37	37	37	37

Data on Bourbon returns from SWT (37 months from October 2014 to November 2017) and whiskyauction.com data (102 monthly returns from April 2011 to October 2019). We obtain Mkt-RF, SMB, HML and MOM monthly data for the sample period from Ken French's data library (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html). We add monthly liquidity factor returns from Robert Stambaugh's website (http://finance.wharton.upenn.edu/~stambaug/liq_data.1962.2019.txt). Standard errors in parentheses.

A Appendix A

Table A1 provides an example of the data structure required to perform a repeat sales analysis. The table highlights the intuition behind the repeat sales method. In particular, the log price relatives r are the difference between the sale price in time t and $t - 1$ for each product (in the table, products A and B). These log price relatives are then regressed on the “time period” variables.

In such a regression, and because the dependent variable is roughly equal to a percentage price change for the various products, the estimated difference, on average, between β_3 and β_4 has to be the best estimate of the difference in the percentage price increase (as captured by the log price relative) between time periods $t = 3$ and $t = 4$ across all products.

Table A1: Sample of Repeat Sales Data Structure

Product	Price	r	t	t=1	t=2	t=3	t=4	t=5	t=6	t=7	t=8
A	1	.	1	1	0	0	0	0	0	0	0
B	2	.	1	1	0	0	0	0	0	0	0
A	1.11	.	2	-1	1	0	0	0	0	0	0
B	2.69	.	2	-1	1	0	0	0	0	0	0
A	2.07	0.273	3	0	-1	1	0	0	0	0	0
B	3.67	0.135	3	0	-1	1	0	0	0	0	0
A	2.65	0.108	4	0	0	-1	1	0	0	0	0
B	4.19	0.058	4	0	0	-1	1	0	0	0	0
A	2.72	0.011	5	0	0	0	-1	1	0	0	0
B	4.96	0.073	5	0	0	0	-1	1	0	0	0
A	2.78	0.009	6	0	0	0	0	-1	1	0	0
B	5.22	0.022	6	0	0	0	0	-1	1	0	0
A	2.86	0.014	7	0	0	0	0	0	-1	1	0
B	5.73	0.041	7	0	0	0	0	0	-1	1	0
A	3.62	0.102	8	0	0	0	0	0	0	-1	1
B	6.52	0.056	8	0	0	0	0	0	0	-1	1

Sample data structure required for a repeat sales regression analysis.

B Appendix B

Here, we present annual asset returns along with summary information on volatility, distribution characteristics, and risk-adjusted performance in Table B1.

Table B1: Investment Performance: Portfolio Returns (Annual)

	Mean returns per annum		Dispersion of annual returns	
	Geometric	Arithmetic	Standard deviation	Sharpe Ratio
<i>Nominal Returns</i>				
Bourbon (Auction) N=102	8.21%	17.48%	43.74%	0.40
Bourbon (Peer-to-peer) N=37	18.16%	19.78%	27.51%	0.72
Stocks (SPY)	11.17%	11.95%	12.54%	0.95
Bonds (BND)	3.31%	3.36%	3.28%	1.03
Commodities (DBC)	-8.44%	-7.21%	15.58%	-0.46
Inflation	1.59%	1.59%	1.01%	1.57
60/40 Stocks Bonds	8.24%	8.51%	7.48%	1.14
with 5% Bourbon (Auction)	8.76%	9.01%	7.09%	1.27
50/30/20 Stocks/Bonds/Commodities	5.21%	5.54%	8.22%	0.67
with 5% Bourbon (Auction)	5.16%	5.46%	7.82%	0.70
<i>Real Returns</i>				
Bourbon (Auction) N=102	6.65%	15.89%	43.64%	0.36
Bourbon (Peer-to-peer) N=37	16.95%	18.54%	16.81%	1.10
Stocks (SPY)	9.58%	10.35%	12.49%	0.83
Bonds (BND)	1.71%	1.77%	3.49%	0.51
Commodities (DBC)	-9.99%	-8.80%	15.30%	-0.58
60/40 Stocks Bonds	6.65%	6.92%	8.10%	0.85
with 5% Bourbon (Auction)	7.17%	7.41%	7.04%	1.05
50/30/20 Stocks/Bonds/Commodities	3.62%	3.95%	8.10%	0.49
with 5% Bourbon (Auction)	3.58%	3.87%	7.71%	0.50

Notes: Bourbon returns estimated from whiskyauction.com data from 2011 to 2019 and from Sweet Water Trading data from 2014 to 2017 using a repeat sales approach. CPI from the Bureau of Labor Statistics. SPY = Standard and Poor's Depository Receipt S&P 500 Exchange Traded Funds Trust, BND = Vanguard Total Bond Market Exchange Traded Funds, DBC = Invesco DB Commodity Index Tracking Fund