Additional Material

February 6, 2023

This document contains information and details that have been removed from the main paper, as well as a more extensive literature review divided by topic.

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1 Additional information related to introduction

1.1 Complexity of emotional dividends' time variation

The emotional part of the valuation, which we call the convenience yield, is hard to measure. In a summary article, Goetzman et al (2021) argue that collectors' tastes and associated valuations are difficult to model economically but may have first-order effects. Goetzmann, Mamonova, & Spaenjers (2015) also argue that variation in past aesthetic experiences, social signaling, identity constructions and many other factors impact differences in tastes. Our paper does not strive to explain an emotional yield but rather to propose a method for estimating it and examining how it relates to prices in equilibrium.

1.2 Non-pecuniary utility and illiquid markets

Our study sheds light on the impact of non-pecuniary utility, which plays an important role in illiquid markets. The role of non-pecuniary utility is important for entrepreneurial

[1] We will keep updating the literature review to incorporate more recent papers. The last update was in April 2021.

investments and economic lifestyle. Moskowitz & Vissing-Jorgensen (2002) attribute the explanation of a puzzle why households willingly invest substantial amounts in a single privately held firm with a seemingly far worse risk-return trade-off to large non-pecuniary benefits from investment in private equity. Non-pecuniary return is argued to be the source of investment in prestigious hedge funds (Statman, Fisher, & Anginer, 2008), socially responsible mutual funds (Bollen, 2007; Renneboog, Ter Horst, & Zhang, 2011; Dimson, Karakaş, & Li, 2013) and art (Stein, 1977; Mandel, 2009). Non-pecuniary utility can impact stock price of despised stocks (Hong & Kacperczyk, 2007). Thus, our concept of convenience yield can be applied to the vast majority of private value assets that yield emotional returns.

1.3 Additional details about FMPs

The intuition behind our measure of convenience yields is that the expected total return of collectibles, combining the financial and non-financial returns and netting out transaction & holding costs, should equal the expected total return of the collectible-specific factor mimicking portfolio, which has only financial returns. Our mimicking portfolio preserves two attributes. It is composed only of liquid and easy to trade assets and it retains only a small amount of return volatility which is not explained by the pervasive risk factors. The basic multiple-factor paradigm stipulates that the return on any asset, say stock j observed over an interval ending at time t, can be written as a linear function

$$R_{j,t} = \alpha_j + \beta_{j,1} f_{1,t} + \beta_{j,2} f_{2,t} + \cdots + \beta_{j,K} f_{K,t} + \epsilon_{j,t} \tag{1}$$

where the f's denote the pervasive factors while the β's are factor sensitivities. Let $k = 1, \ldots, K$ be the index for the global factors. α is an intercept and ϵ is a residual or diversifiable risk that is unrelated to the factors and is also uncorrelated across individual assets. Our asset j is the "target asset" (collectibles in our case) for which we want to form a mimicking portfolio.

We construct mimicking portfolios of collectibles in the spirit of Roll & Srivastava's (2018) who construct mimicking portfolio as the portfolio that minimizes idiosyncratic risk while retaining the same loadings on the global factors for target asset j.

The returns of a well-diversified portfolio are driven by the non-diversifiable factors in (1). The remaining residual risk is minimal because residuals in (1) are uncorrelated across assets within the portfolios and thus should be diversified. The returns of a full diversified portfolio p would be:

$$R_{p,t} = \alpha_i + \beta_{i,1} f_{1,t} + \beta_{i,2} f_{2,t} + \cdots + \beta_{i,K} f_{K,t} \tag{2}$$

where the pervasive factors, f's, are the same in (2) as in (1) but the factor sensitivities β and α in (2) are weighted-average over the individual assets (basis asset) in the entire portfolio. There is no ϵ as it is diversified and thus the return variation of this completely diversified portfolio is driven by f's through the sensitivities (β). Mimicking portfolio p constitutes basis assets including 57 bond and stock indices from all around the world.

1.4 Details on implementation

In this study, the return variability of our mimicking portfolio (p) can be explained by pervasive factors, which are constructed as the principal components (PCs) that explain 90% of eigenvalues. We use stocks and bonds indices from all around the world to construct our PCs and form mimicking portfolios because the collectibles are traded globally. We include lead and lag of these PCs to alleviate autocorrelation concern (Dimson, 1979). To address potential overfitting from applying multiple factors, we implement not only ordinary least squares, but machine learning-based dimension reduction techniques such as lasso, ridge, elastic net and partial least squares (PLS) regression.

1.5 Reworded contributions

Our study contributes to the literature in several aspects. First, we collaborate the collectibles literature. We join a group of the studies that value art (Renneboog & Spaenjers, 2013; Goetzmann, Renneboog & Spaenjers, 2010), cars (Laurs & Renneboog, 2018), wine (Dimson, Rousseau & Spaenjers, 2015), stamps (Dimson & Spaenjers, 2011), fine pens (Tomkovick & Dobie, 1995) and etc. The literature has attempted to estimate the numerical value of these collectibles and shed light on their diversification benefit. However, not many of them successfully quantify the emotional part of the equation. We explain some studies that attempt to achieve this below.

Second, we advance a branch of the literature that theoretically attempts to estimate the non-financial value of collectibles. Goetzmann & Spiegel (1995) construct a simple model where investors pay for art based on their private value. Mandel (2009) present an asset pricing model in which a conspicuous consumption utility dividend endogenously lowers the average returns on art investments. Jovanovic (2013) and Dimson, Rousseau & Spaenjers (2015) examine whether wines that are associated with high emotion dividends generate lower financial returns. Lovo & Spaenjers (2018) propose a model that agents make trading decisions based on their private value. None of these papers propose a methodology of estimating convenience yield and empirically estimates it.

Third, we specifically contribute to the research that attempts to quantify convenience yield. We are not the first that make such an attempt. There are three approaches that the literature has proposed. First, is to use rental price to capture emotional returns of art (Atukeren & Seckin, 2007). This approach relies on price charged for rental service, which is hardly or not even available. Second is to use alpha from factor models as net emotional returns. Hodgson & Vorkink (2004) interpret alpha as emotional returns net transaction costs. The drawback of this approach is it depends on the right factor model. Different collectibles should be priced differently and explained by different asset pricing models. Even for equities, what is the right model is still inconclusive. For collectibles which have both pecuniary and non-pecuniary components, it is even more difficult to establish the right asset pricing model. The studies that apply this approach just use CAPM without validating the choice of the model. The third approach relies on the assumption that the financial return of collectibles is lower than the returns of traded assets such as stocks and bond and uses the difference between the stocks and bonds return, and collectibles returns as convenience yield (Stein, 1977). The problem of this method emerges when collectibles yield both financial and emotional returns higher than other investments. If that is a case,

we cannot argue that the difference between lower return on stocks and bonds and higher return on collectibles presents convenience yield of stocks and bonds.

In short, these approaches are appealing as they are simple, but not necessarily adequate and theoretically grounded. The requirement that collectibles returns be lower than other financial investment is not always achievable. Our approach is simple to implement, rationally and rigorously estimated, and can be applied to any collectibles.

Fourth, we also contribute to the factor mimicking portfolio literature. Factor mimicking portfolios have been widely used in asset pricing literature. The technique has been commonly used for non-traded assets such as consumption and macro variables. Readers can apply our approach to mimic the returns and variance of any collectibles using traded assets. It is known that private value assets including collectibles lack of publicly data. The price is also stale and thus causes autocorrelation, which bias the estimation. This issue demands researchers to apply sophisticated techniques. As well, collectibles are associated with storage, maintenance, insurance, search, and transaction costs. With mimicking portfolios, investors can diversify idiosyncratic risk while letting the return of mimicking portfolio to be explained by the same the pervasive factors that explain the return variability of collectibles. Investors can construct mimicking portfolios that bear lower transaction costs, yet have liquidity that allows them to trade more freely in a public market. Mimicking portfolios also provides comfort to investors as the underlying assets are traded in the more transparent and better governed public markets. Our study proposes a technique that investors can apply in the real world.

1.6 Less important contributions

Fifth, our study also sheds light on the application of machine learning in illiquid markets. Machine learning has experienced more uses in private return markets. To name a few, Aubry et al (2020) use purpose-built machine-learning algorithm that considers both visual and non-visual artwork characteristics to predict price of artworks in the auction market. Fuster et al (2020) apply machine learning to evaluate whether mortgage lenders apply a fair price. We complement this line of research using machine learning to handle big data and factors zoo by applying various dimension reduction techniques to handle the inclusion of multiple factors. The techniques we have used have been applied widely recently in asset pricing literature. For instance, Giglio and Xiu (2020) apply Lasso to select price risk factors from the factor zoo. Kelly and Pruitt (2013) apply partial least square to asset pricing and Huang et al (2015) apply it to sentiment measure and find it can strongly predict returns.

Finally, our study satisfies a commensurate need to understand the literature on tokenization, that is still in infant stage but observe explosive growth and attention (see the example of non-fungible Token, NFT). Our method should have a potential to value the emotional return of this fast-growing asset once the data becomes sufficiently available. Vorsatz (2020) develops a model of tokenization and argues that it can be welfare improving. Whitaker & (20202) argue that a fractional equity system for artworks can be a channel for investors to diversify their portfolio and liquid access to the art market. This tool allows artists to retain a share and capture the value in the upside potential of their artworks.

1.7 Other snippets

Friede, Busch, & Bassen (2015) review more than 2,000 published empirical studies and show roughly 90% of studies find a nonnegative relation between sustainability and stock performance. However, this question is plagued by reverse causality and other studies like Gillian, Koch, & Starks (2020) have found mixed evidence.

2 Original Literature Review[2]

In this section, we start with the literature that gives us a background on collectibles, their financial returns and diversification benefit. We then present the studies that show the evidence of non-pecuniary utility from sustainable investment and then the studies that attempt to tie the impact of psychic dividend on price from those investments. In general the results still remain inconclusive due to the lack of time series that is long enough and the change in tastes and hedging risks. Our study fills in this gap. Our review is by no means an exhaustive list of the works in the literature. We try to include the works that are the closest to ours.

2.1 Collectibles and financial returns

Collectibles make up a non-negligible proportion of total household wealth and are gaining popularity as portfolio diversifiers. In contrast to financial assets that are contractual claims to benefits such as ownership and flow of income, most collectibles are unique and provide personal enjoyment; no perfect substitute can be purchased elsewhere, which increases the motives of holders to own that object. The price of any collectible should have a portion that can be thought of as being paid in exchange for immediate consumption by purchasers. Since most collectibles can survive in close to their original condition for centuries, some portion of the price should also be thought of a present value of the sums that may be paid by future owners in exchange for the consumption or pleasure they can obtain from collectibles. Thus, in contrast to traded assets, there are two uncertainties associated with collectibles. One is attributable to personal tastes which differ among potential owners. Another is the uncertainty in tastes over time.

Prices of collectibles are determined by the intersection of the distribution of purchasing power and that of tastes. Researchers have applied two methodologies to construct the index of collectibles. First is hedonic regression, which depends on collectible characteristics. Second is arithmetic repeat-sales regression.

Lately, researchers in this branch have applied machine learning to predict and enhance our understanding of collectible prices. The advantage of machine learning is it captures the subtleties of the pricing of style and features detectable optically. Elgamma & Saleh (2015) quantify creativity in artworks using computer algorithm and network between creative products. They infer the originality and influence of its nodes from network. Whether this originality is priced is an open question. Other researchers value artworks from color

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(see Pownall & Graddy, 2016; Ma, Noussair, & Renneboog, 2019). The first paper finds the intense and darkness in color carry premium while the latter finds blue, and red are associated with stronger buy. Glaeser, Kincaid & Naik (2018) apply visual recognition technique to predict housing prices. Goetzmann, Jones, Maggioni, & Walden (2016) consider characteristics associated with art and apply clustering analysis to group artists with similar style based on their price dynamics. The algorithm classifies artworks into five groups, which are are consistent with a standard classification of style. Although researchers propose different methods to value or understand the price of collectibles, how to disentangle taste from value is still unresolved. We attempt to resolve this question.

2.2 Collectibles and diversification benefits

Collectibles also provide an option to investors to diversify their portfolios. Dimson & Spaenjers show art, stamps and violins from 1990-2012 yield 6.4%-6.9% in minimal terms or 2.4%-2.8% in real term. Collectibles have higher average returns than bonds, bills and gold; however, the volatilities of price and transaction costs are also high. Renneboog & Spaenjers (2013) show that the Sharpe ratio of art is higher than of other popular alternative asset classes such as commodities and real estate, though it is below that of stocks and bonds.

2.3 Theoretical framework of sustainable investment and return in equilibrium

Fama & French (2007) examine the effect of investor biases and tastes on asset pricing while treating firm behavior as exogenous. Their taste can be applied to emotional yield from socially responsible investing or collectibles investing. Henkel, Kraus & Zechner (2001) construct a general equilibrium model where firms and investors are jointly optimizing. Their model predicts lower stock prices of polluting firms and thus increase cost of capital. If the higher cost of capital overcomes the cost of reforming, firms will become socially responsible. Baker et al (2018) reach the same conclusion with different setting. The first two papers use calibrations to study the potential impact of tastes on asset pricing and match these calibrations to moments in the data. Baldauf, Garlappi, & Yanneli (2019) emphasize the importance in belief, which is analogous to taste in our context about risk, to how, or if, it is priced.

Engel et al (2020) construct mimicking portfolios to build portfolios that are hedged against shocks in climate change news. They use textual analysis of newspapers, construct a series of shocks related to climate change , and use mimicking portfolio approach to build climate-change-news hedge portfolios. They find their constructed mimicking portfolios successfully hedge the shocks in climate change out of sample. If the climate change news is a good proxy for underlying climate change risks, their mimicking portfolio approach will serve as a hedge against climate change risks.

Baker et al. (2018) build a model featuring two types of investors with mean-variance preferences, where one type also has tastes for green assets. In contrast, Pedersen, Fitzgibbons, & Pomorski (2020) consider the same two types of mean-variance investors, but also add a third type that is unaware of firms' ESG scores and illuminate both the potential costs and benefits of ESG-based investing. This lack of awareness is costly if firms' ESG scores

predict their profits. They show that stocks with higher ESG scores can have either higher or lower expected returns, depending on the wealth of the third type of investors. They obtain four-fund separation and derive the ESG-efficient frontier characterizing the tradeoff between the ESG score and the Sharpe ratio empirically. They provide an ESG CAPM framework and emphasize how investor beliefs and preference regarding climate change risk fit into the factor model.

Pastor, Stambaugh, & Taylor (2020) develop an equilibrium model predicting agents with stronger ESG preferences earn lower expected returns because they derive utility from their holdings – however, they sacrifice less financial return than they are willing to. This suggests the psychic dividends more than compensate lower financial returns. They conclude green assets can outperform in terms of financial returns if: (1) tastes unexpectedly become greener; or (2) a green-related risk emerges (eg: climate change worsens unexpectedly). Their conjecture suggests our convenience yield estimate may be a lower bound. Albuquerque, Koskinen, and Zhang (2019) construct a model where sustainable investment improves customer loyalty, giving the firm more pricing power, which consequently results in less risk and more value to a firm. Andonov, Kräussl, & Rauh (2021) highlight the importance of tastes. They argue that ESG considerations of public institutional investors, such as public pension funds, sovereign wealth funds and government agencies, can partially explain their underperformance in infrastructure. Such investors thus seem willing to trade off financial returns against non-pecuniary benefits, in a way similar to impact investors in the venture capital industry and mutual fund as described below. Variation in tastes is more likely to affect investor prices and returns in illiquid markets. Our results support the conjecture derived from these theories as we show convenience yield is price.

2.4 Sustainable investment and non-pecuniary benefits

Section 2.3 presents the studies that provide a theoretical framework between sustainable investment and non-pecuniary benefits, but do not attempt to empirical test due to data. In this section, we present some papers show the empirical evidence between sustainable investment and non-pecuniary benefit. This view is evident in mutual funds. Examining US equity mutual funds with SRI purpose, Bialkowski & Stark (2016) find that inflows to these funds are higher than inflows to comparable non-SRI funds and the SRI flow is less sensitive to performance. Hartzmark & Sussman (2019) also provide similar evidence. They find mutual fund flows increases with ESG rating and explain this is due to ESG-salient information, such as Morningstar sustainability ratings. Bollen (2007) shows flows to socially responsible investment mutual funds are more stable than otherwise and Renneboog, ter Horst, & Zhang (2011) find mutual fund flow of socially responsible funds is less sensitive to negative past performance. Some studies conduct surveys to the members of pension funds and find similar evidence. Riedl & Smeets (2017) show investors in SRI funds demand lower returns and are willing to pay high management fees. The driver of this forgoing financial performance seems to be social preferences and social signaling. In a following up study, Bauer, Ruof, & Smeets (2020) conduct a survey on a majority of Dutch pension participants and find the majority voted for the fund to increase its focus on sustainability. Social preferences, not financial beliefs or confusion, seem to drive their finding. The same evidence is seen in venture capital funds. Analyzing the flows of limited partner investment across venture capital funds, Barber, Morse & Yasuda (2017) reach similar conclusion.

2.5 Empirical evidence of sustainable investment and returns

The studies in Section 2.4 provide the evidence of sustainable investment and non-financial benefits in general, but do not attempt to estimate the returns. In this section, we present the research that attempts to show how it relates to financial returns; yet, the evidence is largely inconclusive. Friede, Busch & Bassen (2015) show there have been more 2,000 published empirical studies in management accounting, finance and economics examining this relation. They conclude roughly 90% of studies find a nonnegative relation between doing good and performance. However, this question is plagued by reverse causality. Are firms that do good do well, or firms that do well do good? Gillian, Koch & Starks (2020), in contrast to Friede et al (2015), focus on corporate finance studies and find the conclusion is mixed. They also emphasize a void how the impact of sustainable investment on return is reflected in stock price. Some papers find high value today and low returns going forward because sustainable investment is priced correctly. Others find low values and high future returns because sustainable investment is initially mispriced. They argue it is essential to reconcile the disparate finding on social investment and measure of value. We attempt to fill this void.

A group of studies shows assets that are associated with social norm and image underperform. The main argument is investors demand less returns as they gain from non-pecuniary utility. Hong & Kacperzyck (2009) find sin stocks outperform non-sin stocks. They find sin stocks are cheap and thus undervalued compared to non-sin stocks. Baker et al (2018) study green bonds or bonds whose proceeds are used for environment friendly purpose and find green municipal bonds are issued at a premium with yield of 5-8 bps lower to otherwise similar ordinary bonds and the bonds that are externally certified as green experience with 8-19 bps. Zerbib (2019) examines green bonds during 2013 to 2017 and finds they are priced at a premium on comparable non-green corporates with yields on green bonds was 2 bps lower. Chava (2014), El Ghoul et al. (2011), and Albuquerque et al (2018) show greener firms have lower systematic risk and thus lower cost of capital.

In contrast, some studies find sustainable investment outperforms. Edmans (2011) shows firms that have higher employee satisfaction and better governance outperform. Firms that have strong holder rights and higher ESG rating outperform (Gompers, Ishii, & Metrick, 2003; Kempf & Osthoff, 2007, respectively). Pedersen et al (2020) strive to reconcile the difference in these findings. They argue when there are many ESG-unaware investors and when high ESG predicts high future profits, they find high ESG stocks deliver high expected returns because high ESG stocks are profitable yet their prices are not raised by ESG-unaware investors, causing high future returns. When there are many ESG-aware investors, they will bid up the prices of high ESG stocks to reflect their expected profits and thus make the relation between ESG and expected returns neutral. Lastly, when there are many ESG-motivated investors, high ESG stocks deliver low expected returns because these investors are willing to accept lower return for a higher ESG portfolios. According to our results of collectibles, it seems collectible investors are more motivated by non-pecuniary benefits from collectibles investment and thus we find the negative relation between convenience yield and financial returns.

The inconclusive evidence might also be due to the difference in sample period and datasets. Sustainable investment has just gained attention recently, thus the data might not be long enough for researcher to test and achieve good statistical power. Besides, the non-pecuniary

benefit from socially responsible investment is difficult to disentangle from changing tastes and hedging aggregate risk in the Pastor, Stambaugh & Taylor (2020) framework. Non-financial utility from collectibles is insulated from these issues and the data of collectibles is long enough. These assets have been popular investments for centuries and can be used to examine how emotion yields impact price in equilibrium.