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Can Vice be Vindicated?

Examining a potential value premium in vice stocks using Fama and MacBeth regressions – a comparison across three different factor models

BACHELOR'S THESIS IN FINANCE

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Abstract

In this paper, we examine a 30-year period to find whether vice (defined as operations in the alcohol, tobacco, gambling, adult services, and weapons and defense industries) plays a role in determining returns of individual firms on the U.S. stock market. We find no evidence that vice can be expected to affect returns, but rather that expected effects from vice are priced by other factors. However, our analysis does not lead us to conclude that either of the examined risk factors explain the variability in our vice factor. Furthermore, we examine whether vice stocks are associated with a premium. We are not able to conclude that such a premium exists.

Keywords: Vice stocks, asset pricing, risk premiums, Fama and MacBeth

JEL Classifications: G11, G12

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I. Introduction

Judging by the level and growth of assets under management (AUM) according to responsible investing principles, it appears as sustainable development, corporate social responsibility (CSR), and environmental awareness have become important parts of all aspects of business. AUM according to responsible investing principles reached \$8.7 trillion in 2016, and the figure had been rising. Approximately 1 out of every 5 dollars under professional management in the United States are invested using socially responsible investment (SRI) principles.¹ This phenomenon could bring about a significant change in finance – where the goal of maximizing return on investment (ROI) must be aligned with an increased focus on sustainable practices. This could have implications for the pricing of stock in firms not deemed to be responsible. In this paper, we examine whether vice stocks (defined as stocks in firms with operations in the alcohol, tobacco, adult services, gambling, and weapons and defense industries) have become undervalued and have a premium. We also attempt to find if vice plays a role in determining individual stock prices. Our research is made up from a) testing whether effects of vice are explained by other risk factors, b) researching vice premia using Fama and MacBeth (1973) regressions. We find no evidence that vice can be expected to affect returns, but rather, that expected effects from vice are priced by other factors. Neither do we find evidence of an existing vice premium.

Fama and French (2007) discuss the consequences of pursuing non-financial goals while investing in the stock market. They address the illogicality of the assumption that investors pursue only financial goals while investing in the stock market. Fama and French (2007) also imply that investors who reject vice stocks for non-financial reasons tend to overweight SRI-focused firms in their portfolio. In turn, this could mean a risk of having an undiversified portfolio and therefore lower risk-adjusted returns. There are, however, studies showing that responsible investing does not necessarily mean lower returns. Auer (2016) shows that for the European stock market, using SRI screening does not mean financial underperformance. In fact, it seems possible to outperform the market using SRI investing. Also, Hill et al. (2007) show that corporate social responsibility

¹ US SIF – 2016 Report on Sustainable and Responsible Investing Trends.

(CSR) seems to be able to have a positive impact on firm value over a long-term horizon for U.S., European, and Asian companies.

The definition of a vice stock is not completely straightforward, and many alternatives have been proposed, as described by Fauver and McDonald (2014). They explain that perceptions of vice differ across cultures, religions, and even geographical areas. For example, the authors mention that alcohol is regarded as highly sinful in Saudi culture, while tobacco is not. Furthermore, in their analysis of the G20 countries, with its diverse composition of nations, they conclude that firms may have different valuations in different markets. Their finding is that a higher level of perceived vice means a lower valuation in the local markets. There is also a time aspect to be considered, since the perception of what is regarded as a vice is not constant over time.

Throughout this paper, we define a vice stock as stock in a firm with operations in one or several of the following industries: tobacco, alcohol, adult services, gambling, and weapons and defense. This follows directly from the classification used by Fabozzi et al. (2008) with the exception that we do not include the biotech sector in our analysis. As pointed out by Fauver and McDonald (2014), many nations regard this industry as highly important for the future (South Korea being one example) and not as a vicious industry.

There is research supporting that investing in vice stocks increases the returns in a portfolio. For example, Fabozzi et al. (2008) show that vice stock portfolios outperform benchmark portfolios in 35 out of 37 years examined. Similarly, Hong and Kacperczyk (2009) have concluded that investors, including pension funds, lower their returns by excluding vice stocks from their portfolios. Their paper, however, utilizes a narrower definition of vice, and only include the alcohol, tobacco, and gambling industries in their samples. Chong, Her, and Phillips (2006) examine the performance of a mutual fund with a broad vice stock focus² in comparison with a mutual fund with a focus on SRI.³ During a three-year period, the vice-focused fund outperformed both the S&P 500 Index and the SRI fund.

² The USA Mutuals Vice Fund

³ The Domini Impact International Equity Fund

Other research casts doubt on the potential of vice stocks to generate superior returns. In a study by Durand, Koh and Tan (2013), where seven pacific countries in Asia and Oceania are examined, the conclusion is made that sin stocks performed worse than the markets in all of the seven countries. Areal, Cortez and Silva (2013) examine how the USA Mutuals Vice Fund performs in comparison to a collection of funds focused on socially responsible investing (SRI). Special focus is placed on examining different periods of low and high volatility. Using the Capital Asset Pricing Model (CAPM) and the Carhart (1997) Four-Factor Model, they show that the vice fund does in fact perform worse than the SRI funds during periods of high volatility, which is contradictory to the claim of the Vice Fund's managers that it should perform better during recessions. In a paper by Lobe and Walkshäusl (2016)⁴, separate portfolios with vice and SRI stocks are constructed. Using the vice portfolio as a long position, and the virtue portfolio as a short position, a hedge is formed. Analyzing this hedge with the CAPM, the Fama and French (1993) Three-Factor Model, the three-factor model by Chen et al. (2010), and the Carhart (1997) Four-Factor Model, they find the hedge to be inefficient in generating returns that outperform those of the market. They do, however, show that vice stocks have a lower market beta than virtue stocks, indicating a lower market risk for vice. Our research is differentiated from this paper in that we a) exclude the CAPM and the Chen et al. (2010) three-factor model, and include the Fama and French (2015) Five-Factor Model, b) construct our vice and virtue portfolios from firms in different industries, c) perform Fama and MacBeth (1973) regressions, d) use a longer time frame, e) utilize a sliding window approach.

We base the analysis in this paper on the hypothesis that investors can outperform the market by investing in vice stocks. This leads us to our first hypothesis:

H1: Vice stocks carry a premium

The intuition behind our hypothesis is that an increased focus on responsible investing would lead to systematic divestment from sin stocks, which should cause said stocks to become undervalued in relation to their economic fundamentals. This undervaluation would give vice stocks a higher expected return – a premium. If the Efficient Market Hypothesis (EMH), as formulated by Fama

⁴ This paper came to our attention just at the end of our own research.

(1970) is assumed to be valid, we should not be able to find that vice stocks are undervalued, since they would already be fairly priced. For example, an increased focus on sustainable practices could mean declining real demand for products and services offered by vice firms. Divestment for such reasons would not lead to undervaluation per se, but rather the fair price being driven down.

While there are plenty of earlier papers examining this by comparing the returns of vice stocks with virtue stocks (Chong, Her, and Phillips, 2006; Areal, Cortez and Silva, 2013; Lobe and Walkshäusl, 2016) and the broader markets (Fabozzi et al., 2008; Hong and Kacperczyk, 2014; Durand, Koh and Tan, 2013), there is limited research on whether vice, in and of itself, can be used to explain returns in individual firms. This is the driver of our second hypothesis:

H2: Vice can be used to explain the stock returns of individual firms

We reason that if vice, as such, is assumed to affect the behavior (that is, how securities are being bought and sold) of investors in the markets, then it can also be assumed to affect the prices of individual assets.

The remainder of the paper is structured as follows. Section II lays down the foundation and the theoretical framework of our paper. Section III describes our data and its delimitations. Section IV shows the methodology of our research. Section V reports the main findings of our study. Section VI contains a check on robustness. VII consists of our analysis of the findings, as well as a discussion of the limitations to our methodology. Finally, section VIII concludes the paper.

II. Theoretical framework

The theoretical foundation of our research stems from models described by Fama and French (1992, 1993, 2015), and Carhart (1997). These papers present risk factor models that can be used to explain the return of individual stocks. Our analysis of returns draws directly upon each of the three models that are described in these papers. The models are summarized below:

Fama and French (1993) Three-Factor Model (FF3):

$$R_t = \alpha + \beta_1MKT_t + \beta_2SMB_t + \beta_3HML_t + \epsilon_t,$$

Carhart (1993) Four-Factor Model (CAR):

$$R_t = \alpha + \beta_1MKT_t + \beta_2SMB_t + \beta_3HML_t + \beta_4MOM_t + \epsilon_t,$$

Fama and French (2015) Five Factor Model (FF5):

$$R_t = \alpha + \beta_1MKT_t + \beta_2SMB_t + \beta_3HML_t + \beta_4RMW_t + \beta_5CMA_t + \epsilon_t,$$

where R_t is the monthly stock excess return at time t , MKT_t is the market excess return at time t over the one-month Treasury bill rate, SMB_t is a measure of the difference, on average, in returns at time t between small and big firms, HML_t is a measure of the difference, on average, in returns at time t between firms with high and low book-to-market equity, MOM_t is a measure of the difference, on average, in returns at time t between firms with positive and negative momentum, RMW_t is a measure of the difference, on average, in returns at time t between firms with robust and weak operating profits, CMA_t is a measure of the difference in average returns at time t between firms with conservative and aggressive investment strategies. A detailed description of each factor is provided in Appendix A.

The rationale behind these factors are that small firms earn better returns than large firms, and that a similar relationship exists between firms with high and low book-to-market equity, robust and weak operating profits, firms with a positive stock price trend and a negative momentum⁵ and conservative and aggressive investment policies. Therefore, each of the factors essentially consists of both a long position (in firms with low market capitalizations, high book-to-market equity, positive momentum, robust operating profits, and conservative investments) and a short position (for firms with the opposite characteristics). Our justification for analyzing three separate models

⁵ Defined as the 12-month stock price trend.

is that we want to examine the interplay between vice and different sets of other risk factors, as to make our analysis more complete.

In a 1973 paper, Fama and MacBeth devise a straightforward method of finding the premium for any risk factor. The Fama and MacBeth regressions consists of a two-step procedure. The first step is to estimate a time series regression for each asset or portfolio, where individual asset or portfolio returns are regressed on suggested risk factors. The second step is to estimate one cross-sectional regression for each time period, where all asset or portfolio returns are regressed on factor coefficients collected from the first step. The two steps, applied to FF3, CAR, and FF5 are summarized below:

First step of the Fama and MacBeth regression, for each of our models:

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \epsilon_t$$

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \epsilon_t$$

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + \epsilon_t$$

The second step of the Fama and MacBeth regression, for each of our models:

$$R_t = \alpha + \gamma_1 \hat{\beta}_{MKT_t} + \gamma_2 \hat{\beta}_{SMB_t} + \gamma_3 \hat{\beta}_{HML_t}$$

$$R_t = \alpha + \gamma_1 \hat{\beta}_{MKT_t} + \gamma_2 \hat{\beta}_{SMB_t} + \gamma_3 \hat{\beta}_{HML_t} + \gamma_4 \hat{\beta}_{MOM_t}$$

$$R_t = \alpha + \gamma_1 \hat{\beta}_{MKT_t} + \gamma_2 \hat{\beta}_{SMB_t} + \gamma_3 \hat{\beta}_{HML_t} + \gamma_4 \hat{\beta}_{RMW_t} + \gamma_5 \hat{\beta}_{CMA_t}$$

where $\hat{\beta}_{MKT_t}$, $\hat{\beta}_{SMB_t}$, $\hat{\beta}_{HML_t}$, $\hat{\beta}_{MOM_t}$, $\hat{\beta}_{RMW_t}$, $\hat{\beta}_{CMA_t}$ are the loadings on risk factor, collected from the first step of the regression.

III. Data

We base our analysis on the U.S. equity market, due to its size, a large selection of vice stocks available, and the strong prevalence of U.S. data in previous research. Our data is divided in two distinct parts: price data pertaining to the U.S. equity market, as well as data on each of the FF3, CAR, and FF5 risk factors. In addition, we collect data on the one-month risk-free interest rate.

1. Price data

We examine price data on stocks from the New York Stock Exchange (NYSE), NASDAQ, the NYSE American, and the NYSE Arca stock exchanges. We use the U.S. Total Market Index from the Center for Research in Security Prices (CRSP) to proxy for the constituent firms of these exchanges. As of March 2017, the index is made up of 3565 individual firms across all sizes and industries, and represents nearly the current entire investable equity universe in the U.S. The entire dataset is made up of monthly closing prices (or, when such observations are unavailable, average end-of-month bid/ask prices) for the period March 1987 to March 2017. We have chosen this period because a) a time span of 30 years gives a long-term perspective, allowing for comparing and contrasting periods, b) different economic cycles and market climates can be observed, c) the most recent developments are captured by the data. We use monthly data as it is the convention in the literature of our theoretical framework.

In total, our raw data amounts to an approximate 830,000 observations of monthly stock prices. To eliminate survivorship bias,⁶ we sort the stocks on CRSP Permanent Company Numbers (PERMNO), a unique security identification number which remains the same through a security's trading history. This is necessary due to the changes in composition (due to delisting, renaming,

⁶ The tendency for failed companies to be excluded from analysis because they no longer exist.

mergers, etc.) of the CRSP U.S. Total Market Index that occurs over time⁷. In total, we have price data from 5286 individual securities.

The CRSP database provides raw, unadjusted prices, and needs to be adjusted for splits, reverse splits, dividends, and other events affecting the nominal market price of shares of stock. To obtain adjusted prices, adjustments are needed with the Cumulative Factor to Adjust Price (CFACPR), a factor maintained by and available through CRSP. Further, we compute monthly log returns⁸ from the monthly price data, winsorize the returns data outside the 1st and 99th percentiles, and drop all observations where no price is reported. The resulting dataset, which is used for our continued analysis, is summarized in Table 1.

2. Risk factors and the risk-free rate

In addition to price information from the U.S. stock markets, data on the FF3, CAR, and FF5 risk factors, as well as the risk-free interest rate for calculation of excess returns, is needed. We collect monthly data on the *MKT*, *SMB*, *HML*, *MOM*, *RMW* and *CMA* risk factors, as well as the one-month U.S Treasury-bill (used to represent the one-month risk-free interest rate), from the online Kenneth R. French Data Library. All of these inputs are described by Table 2.

IV. Method

1. Creating the vice factor

The first step of the process is to create our virtue and vice portfolios, which we subsequently use to calculate our monthly *VICE* factor.

⁷ For example, in a merger between firms, a completely new PERMNO is generated, even if an earlier ticker is kept.

⁸ Log returns are used for the benefit of being symmetrical, i.e. a 50% price increase followed by a 50% price decrease gives a net effect of $\pm 0\%$.

Table 1
Descriptive statistics of individual firm returns

Table 1 presents descriptive statistics of the monthly returns on all firms in our sample. All inputs are in decimal form.

| | Return |
|-------------------------------|---------------|
| Mean | 0.001281 |
| Standard Error of Mean | 0.000147 |
| Median | 0.003645 |
| Standard Deviation | 0.161115 |
| Kurtosis | 46.96787 |
| Skewness | 1.015707 |
| Range | 0.835696 |
| Minimum | -0.43814 |
| Max | 0.397559 |

Table 2
Properties of risk factors

Table 2 presents summary statistics of all risk factors from the Fama and French Three-Factor Model, Carhart Four-Factor Model, and Fama and French Five-Factor Model. All inputs, except for Count, is presented in decimal form.

| | Mean | Standard Error of Mean | Median | Standard Deviation | Kurtosis | Skewness | Range | Minimum | Maximum | Count |
|-------------------|-------------|-----------------------------------|---------------|-------------------------------|-----------------|-----------------|--------------|----------------|----------------|--------------|
| <i>MKT</i> | 0.0059 | 0.0024 | 0.0116 | 0.0445 | 2.8888 | -0.9669 | 0.3459 | -0.2324 | 0.1135 | 348 |
| <i>SMB</i> | 0.0011 | 0.0016 | 0.0005 | 0.0306 | 5.2959 | 0.4569 | 0.3408 | -0.1533 | 0.1875 | 348 |
| <i>HML</i> | 0.0023 | 0.0016 | 0 | 0.0293 | 2.8176 | 0.123 | 0.24 | -0.111 | 0.129 | 348 |
| <i>MOM</i> | 0.0055 | 0.0025 | 0.0064 | 0.0474 | 11.4067 | -1.5602 | 0.5272 | -0.3439 | 0.1833 | 348 |
| <i>RMW</i> | 0.0034 | 0.0014 | 0.003 | 0.0266 | 11.6502 | -0.4506 | 0.3257 | -0.1906 | 0.1351 | 348 |
| <i>CMA</i> | 0.0028 | 0.0011 | 0.0012 | 0.0205 | 2.3894 | 0.5167 | 0.1644 | -0.0688 | 0.0956 | 348 |
| <i>RF</i> | 0.0027 | 0.0001 | 0.0028 | 0.0021 | -1.107 | 0.1506 | 0.0079 | 0 | 0.0079 | 348 |

1.1 Portfolios

Adhering to our definition of a vice stock, the vice portfolio (our long position) is made to consist of firms whose operations is based in our vice industries. We proxy for these industries by 1) collecting all firms held by the USA Mutuals Vice Fund from its inception on August 30, 2002 until March 2017, 2) compiling firms from the Dow Jones U.S. Tobacco Index, Dow Jones U.S. Brewers Index, Dow Jones U.S. Distillers & Vintners Index, Dow Jones U.S. Gambling Index, and Dow Jones U.S. Defense Index, 3) hand-picking stocks in firearm and adult services companies, as these lack industry classifications of their own and are difficult to screen for. In total, our vice portfolio is constructed to contain 200 individual securities. We utilize equal weighting⁹, meaning that each firm constitutes 0.5% of the entire portfolio. Due to time constraints, we do not filter the fund holdings for firms not adhering to our definition of vice, which is discussed further in the section on limitations. The full list of firms is listed in Appendix B.

To create our virtue portfolio (our short position), we must first define a virtue stock. As with our vice portfolio, we will use an industry-based approach in creating our virtue portfolio. Nonetheless, we feel that matching the vice industries listed above to virtue counterparts cannot be done without a high degree of subjectivity. For example, it could be reasonable to regard the healthcare industry as an opposite of the tobacco and/or alcohol industries, but such an analysis is not as straightforward for the adult services, gambling, or weapons and defense industries. To proxy for virtue stocks, we settle for using the healthcare and life science industries. We use the CRSP U.S. Health Care Index to proxy for these industries. We create the virtue portfolio out of the top 200 constituent firms. As with the vice portfolio, all firms are equally weighted. The full list of firms in the virtue portfolio is listed in Appendix C.

Since the constituents of the CRSP U.S. Total Market are not constant over time (as firms on the NYSE, NASDAQ, NYSE American, and NYSE Arca stock exchanges become listed, delisted, merged, acquired, file for bankruptcy, etc.), our portfolios need to account for these changes in composition. We resample our vice and virtue portfolios at the end of each month. Thus, the

⁹ Given that most firms are large, and that we control for size through the *SMB* factor, we do not feel the need to use value weighting.

Figure 1

No. of firms in portfolios

Chart 1 plots the evolution of the number of firms in each of the vice and virtue portfolios across time.

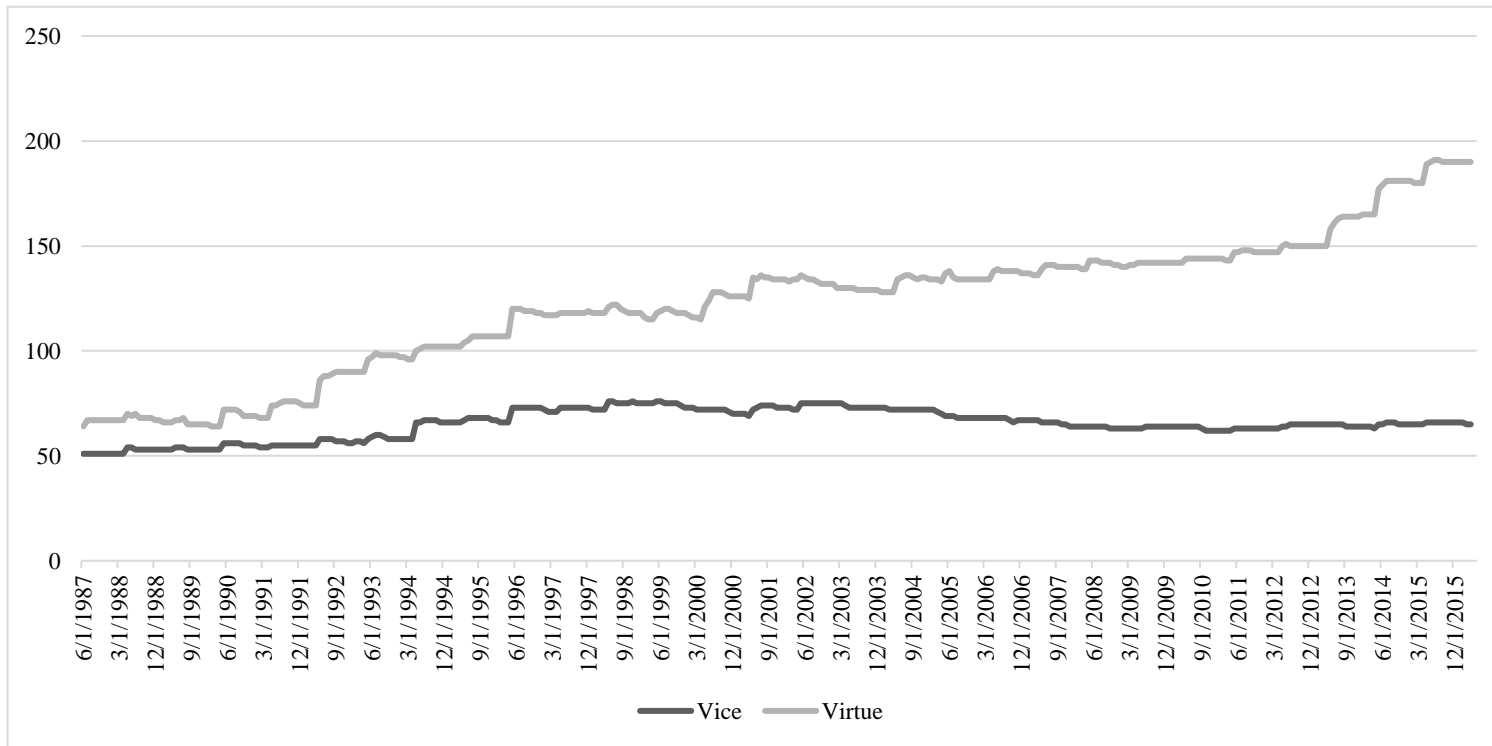


Table 3

Characteristics of the vice and virtue portfolios

Table 3 presents summary statistics of the monthly returns of the vice and virtue portfolios. All inputs are in decimal form.

| | Vice | Virtue |
|-------------------------------|-------------|---------------|
| Mean | 0.0056 | 0.0040 |
| Standard Error of Mean | 0.0028 | 0.0030 |
| Median | 0.0135 | 0.0130 |
| Standard Deviation | 0.0515 | 0.0558 |
| Kurtosis | 6.0709 | 3.2345 |
| Skewness | -1.3890 | -1.1065 |
| Range | 0.5048 | 0.4308 |
| Minimum | -0.3293 | -0.3086 |
| Maximum | 0.1755 | 0.1221 |
| Count | 348 | 348 |

composition of our portfolios changes to match the constituent firms of the CRSP U.S. Total Market Index. Our portfolios are described by Figure 1 and Table 3.

As shown by Figure 1, our vice and virtue portfolios are not necessarily equally populous at any point in time. We do not regard this to be a problem. However, when nearing the end of our examined time frame, the virtue portfolio also grows to contain far more firms than the vice portfolio. This is potentially problematic for our analysis, as we feel that a direct comparison between portfolios with 190 and 65 firms (as is the case in May 2016) is not entirely reliable. However, we argue that a larger problem would be insufficient diversification in the portfolios. Each of the portfolios are sufficiently diversified to make them independently viable for analysis. As shown by Statman (1987), 30 individual stocks are required for sufficient diversification to remove systematic risk. Both the vice and virtue portfolios contain at least 51 individual stocks at each time.

At this stage, we are given an indication of the performance of vice and virtue stocks. The average monthly log return for vice stocks is 0.56% while virtue yields slightly less, 0.40%. Our vice portfolio also displays a lower volatility, indicating that vice stocks can earn better returns despite having lower risk. Observing the range and kurtosis of the portfolios, it seems as though the variance in vice stocks is, to a greater extent than in virtue stocks, explained by fewer extreme observations rather than more frequent, smaller deviations.

1.2 Construction of the factor

With our vice and virtue portfolios, we follow the methodology from Fama and French (1993, 2015) and Carhart (1997) to create our *VICE* factor.

$$VICE_t = R_{VICE,t} - R_{VIRTUE,t}$$

Where $VICE_t$ is our risk factor for vice, $R_{VICE,t}$ is the monthly return of the vice portfolio at month t , and $R_{VIRTUE,t}$ is the monthly return of the virtue portfolio at month t . This is similar to how factors are defined in the papers of our theoretical background.

2. Testing for multicollinearity

To research our second hypothesis, we need to examine whether vice is indeed a determinant of asset prices. With our *VICE* factor created, we run the following regressions:

$$VICE_t = \alpha + \beta_1MKT_t + \beta_2SMB_t + \beta_3HML_t + \epsilon_t$$

$$VICE_t = \alpha + \beta_1MKT_t + \beta_2SMB_t + \beta_3HML_t + \beta_4MOM_t + \epsilon_t$$

$$VICE_t = \alpha + \beta_1MKT_t + \beta_2SMB_t + \beta_3HML_t + \beta_4RMW_t + \beta_5CMA_t + \epsilon_t$$

In statistical terms, this is a simple test of multicollinearity. In economic terms, we are attempting to see whether the effect of vice is priced by the other risk factors. Under our second hypothesis, these models generate significant alphas, meaning that differences in return between vice and virtue portfolios are not completely explained by the other factors of the models. The signs of alphas (positive/negative) will also give some indication as to whether vice can generate superior returns or not.

To complement this test, and to further examine the interplay between risk factors, we look at the pairwise correlations between all of our risk factors.

3. Fama and MacBeth regressions

The second part of our thesis consists of examining a potential premium from exposure to vice, using the methodology from Fama and MacBeth (1973). The Fama and MacBeth regression is a straightforward method of finding factor loadings on returns, as well as premia for risk factors. We estimate the following regressions:

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 VICE_t + \epsilon_t$$

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \beta_5 VICE_t + \epsilon_t$$

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + \beta_6 VICE_t + \epsilon_t$$

Each of these regressions will be estimated with a sliding window, where we examine a period of 5 years at a time, sliding the window one month forward after each regression. The reason is that we do not expect betas to be static over time, but rather highly subject to change.¹⁰

Then, for each month in our sample, we run a cross-sectional regression to estimate the following equations:

$$R_t = \alpha + \gamma_1 \hat{\beta}_{MKT_t} + \gamma_2 \hat{\beta}_{SMB_t} + \gamma_3 \hat{\beta}_{HML_t} + \gamma_4 \hat{\beta}_{VICE_t}$$

$$R_t = \alpha + \gamma_1 \hat{\beta}_{MKT_t} + \gamma_2 \hat{\beta}_{SMB_t} + \gamma_3 \hat{\beta}_{HML_t} + \gamma_4 \hat{\beta}_{MOM_t} + \gamma_5 \hat{\beta}_{VICE_t}$$

$$R_t = \alpha + \gamma_1 \hat{\beta}_{MKT_t} + \gamma_2 \hat{\beta}_{SMB_t} + \gamma_3 \hat{\beta}_{HML_t} + \gamma_4 \hat{\beta}_{RMW_t} + \gamma_5 \hat{\beta}_{CMA_t} + \gamma_6 \hat{\beta}_{VICE_t}$$

where R_t is the monthly stock returns at time t , and $\hat{\beta}_{MKT}$, $\hat{\beta}_{SMB}$, $\hat{\beta}_{HML}$, $\hat{\beta}_{MOM}$, $\hat{\beta}_{RMW}$, $\hat{\beta}_{CMA}$, and $\hat{\beta}_{VICE}$ are the loadings on factors from each risk factor, collected from the first step of the regression. The premium for each risk factor, including the premium on our constructed *VICE* factor, is found by calculating the mean of the gammas for each risk factor.

¹⁰ Preliminary results, where we attempted a static beta approach with a single time series regression, confirmed this to be a more appropriate method. Without the sliding window, highly illogical results were produced (such as negative market premia across models, and other factors showing consistently negative premia).

Due to time constraints, we will limit the Fama and Macbeth regressions to using monthly returns of the constituent firms in the S&P 500 index, rather than running these regressions for every stock in our full sample.

V. Results

In this section, we report the result from the methodology described in the previous section. First, we report our findings regarding multicollinearity and the interplay between *VICE* and the other risk factors. Second, we show the results from our Fama and MacBeth regressions. All tests are done using either Python or Stata.

1. Multicollinearity and interplay between factors

We first run regressions to examine the economic significance of vice as a determinant of firm returns. This test of multicollinearity is summarized in Table 4.

Regressing *VICE* against the risk factors from the FF3, CAR, and FF5 gives insignificant alphas in each case. The effect of vice on individual firm returns seems to be explained by the other factors. This is contrary to our hypothesis, which states that vice does indeed play a role in determining the return of stocks. In addition, the alpha for FF5 is negative, signaling that vice stocks may not outperform the market. These results, taken collectively, would indicate that a) vice does not seem to generate superior returns for firms, b) our vice factor is priced by the other factors, signaling that vice, in and of itself, is not a determinant of stock prices at all.

For FF3 and CAR, *SMB* and *HML* show significance, which is likely to play a role in explaining the insignificant alpha for *VICE* in these models. In the FF5 case, *MKT* is significant, and likely to be one cause for *VICE*'s insignificant alpha. None of the other factors seem to be independently significant when testing for multicollinearity with FF5, however. R^2 for each of the models are relatively low, meaning that much of the variability in *VICE* is left unexplained by the variability in the other factors. In sum, the risk factors from FF3, CAR, and FF5 models seem to be able to

explain the effects of *VICE* on firm returns (as indicated by the insignificant alphas) but not the variability in *VICE* itself (as indicated by the low R^2 .)

Table 4

Results from tests of multicollinearity

Table 4 displays coefficients and t-statistics (in parentheses) from the regression where our vice factor is regressed on risk factors from each of the FF3, CAR, and FF5 models.

*** p<0.01, ** p<0.05, * p<0.1

| | FF3 | CAR | FF5 |
|-------------------|---------------------|---------------------|--------------------|
| <i>MKT</i> | 0.0588 (1.58) | 0.0507 (1.32) | 0.105*** (2.60) |
| <i>SMB</i> | -0.131** (-2.45) | -0.129** (-2.40) | -0.0004 (-0.01) |
| <i>HML</i> | 0.514*** (9.21) | 0.502*** (8.72) | 0.465*** (6.28) |
| <i>RMW</i> | | | 0.386*** (5.30) |
| <i>CMA</i> | | | -0.0991 (-0.93) |
| <i>MOM</i> | | -0.0297 (-0.84) | |
| Constant | 0.0002 (0.14) | 0.0005 (0.28) | -0.0011 (-0.70) |
| Observations | 348 | 348 | 348 |
| R-squared | 0.221 | 0.222 | 0.286 |

The correlation between different factors are displayed in Table 5. While not showing tendencies to co-vary with the broader market, our vice factor displays some correlation with other factors. We suspect that it is these levels of correlation that renders the alpha insignificant in our simple tests of multicollinearity. Independently, not the least is this the case with *HML* (which was also reported as having significance in explaining the effects of *VICE* on firm returns) and *RMW*, both showing correlation with *VICE*. A possible interpretation is that the firms of our vice portfolio have characteristics of high book-to-market equity and robust operating profits.

Table 5
Correlations between risk factors

Table 5 displays pairwise correlation factors for the risk factors from each of the models used, with the significance level of each correlation coefficient in brackets.

| | <i>MKT</i> | <i>SMB</i> | <i>MOM</i> | <i>HML</i> | <i>RMW</i> | <i>CMA</i> | <i>VICE</i> |
|-------------|---------------------|---------------------|---------------------|---------------|--------------------|---------------|-------------|
| <i>MKT</i> | 1 | | | | | | |
| <i>SMB</i> | 0.2084 (0.0001) | 1 | | | | | |
| <i>MOM</i> | -0.1987 (0.0001) | 0.0152 (0.7711) | 1 | | | | |
| <i>HML</i> | -0.196 (0.0002) | -0.1144 (0.028) | -0.2071 (0.0001) | 1 | | | |
| <i>RMW</i> | -0.3787 (0) | -0.4603 (0) | 0.0811 (0.1198) | 0.3467 (0) | 1 | | |
| <i>CMA</i> | -0.3725 (0) | -0.0354 (0.4976) | 0.0335 (0.5212) | 0.6521 (0) | 0.1954 (0.0002) | 1 | |
| <i>VICE</i> | -0.0401 (0.4556) | -0.1696 (0.0015) | -0.1475 (0.0058) | 0.452 (0) | 0.3914 (0) | 0.2165 (0) | 1 |

2. Fama and MacBeth Regressions

2.1 Time Series Regressions

For each of our models, we run separate sliding window time series regressions, one for each stock, where individual firm returns are regressed on the risk factors from our augmented FF3, CAR, and FF5 models. From these regressions, we obtain monthly loadings on factors from each of the risk factors. The main purpose of these is to make possible the calculation of factor premia (for which results are reported in the coming section.)

2.2 Cross-Sectional Regressions

For each of our models, we run separate cross-sectional regressions, one for every month, where monthly returns for all firms are regressed on the coefficients from the first step of the Fama and MacBeth regressions. By averaging the coefficients for each factor, we obtain the premia for that particular factor. Premia for each risk factor across the models are reported in Table 6.

While FF3 and FF5 generates positive premia for vice, with respective values of 0.0003 and 0.0014, the CAR model shows a vice discount of -0.0009. Thus, while the fact that two out of three models show positive premia may be indicative of vice outperforming in the market, we deem our results to be inconclusive as to whether vice stocks have a true premium or not. This is inconsistent with our hypothesis that vice has a premium and higher expected returns, but consistent with some previous studies that also fail to find outperformance by vice. For example, Lobe and Walkshäusl (2016), who adopted a methodology similar to ours, also fail to find conclusive evidence that vice (or, for that matter, virtue) performs better in the equity market.

While inconsistent with our hypothesis, finding conflicting results is not entirely surprising, since our basic tests of multicollinearity indicated a) that vice stocks may not yield higher returns (given the one instance with a negative alpha), b) that vice may not be a determinant of stock returns at all. Furthermore, there are other noteworthy premia in our results of the Fama and MacBeth regression. For FF5, we observe negative premia for *SMB*, *HML*, and *CMA*. On average, we would

expect all premia across models to be positive.¹¹ These anomalies indicate that our findings may be faulty, and we therefore address our results further in our robustness check as well as our discussion of limitations.

Table 6

Premia for risk factors across models

Table 6 reports premia for all risk factors for each of the Fama and French Three-Factor Model (FF3), Carhart Four-Factor Model (CAR), and Fama and French Five-Factor Model (FF5). Premia are found by averaging the coefficients in the second step of the Fama and MacBeth regression.

| | FF3 | CAR | FF5 |
|--------------------|------------|------------|------------|
| <i>MKT</i> | 0.0008 | 0.0008 | 0.0013 |
| <i>SMB</i> | 0.0006 | 0.0000 | -0.0040 |
| <i>HML</i> | 0.0008 | 0.0024 | -0.0015 |
| <i>MOM</i> | | 0.0065 | |
| <i>RMW</i> | | | 0.0056 |
| <i>CMA</i> | | | -0.0010 |
| <i>VICE</i> | 0.0003 | -0.0009 | 0.0014 |

¹¹ Based on the observation that firms constituting the long position in each risk factor do indeed tend to earn higher returns than their short position counterparts.

VI. Robustness

1. Examining market betas

In an attempt to find whether our price data is in any way flawed, we compare price data from our CRSP sample to that of a different source. For a single stock,¹² we regress monthly returns on the risk factors from FF3, CAR, and FF5. This is done with data from both our own sample and from Yahoo Finance. We are examining a) whether coefficients are the same (or close to be the same) for both data sources, which would indicate that our data is correctly gathered, b) whether coefficients seem plausible in both cases. The results from these regressions are summarized in Table 7.

As shown below, the results are highly consistent across data sources, with all coefficients and t-statistics being close to identical for the CRSP and Yahoo data. This indicates that no problems are present in our data collection method. The fact that most coefficients are negative (with the obvious exception of for *MKT*) may indicate that the examined firm has characteristics typical of firms in the short position of each risk factor – that is, large market capitalization, low book-to-market equity, negative momentum, weak operating profits, and aggressive investment policies.

VII. Analysis

Our hypotheses were that a) vice, in and of itself, is a determinant of individual firm returns, b) vice stocks carry premia. We find no evidence that allow us to reject them. However, the results of our paper indicate that what role vice is assumed to play in explaining returns is captured by other risk factors. Our results are also inconclusive as to whether vice stocks have higher expected returns than the market. In this section, we analyze our results, what might be the cause to prevent us from confirming our hypotheses, and provide narrative on the limitations of our research.

¹² For its size and long history of trading, we have chosen IBM.

Table 7
Comparison of regressions between two data sources

Table 8 reports coefficients and t-statistics (in brackets) for risk factors regressed on monthly returns for IBM during our sample period.

*** p<0.01, ** p<0.05, * p<0.1

| | CRSP | | | Yahoo | | |
|------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | FF3 | CAR | FF5 | FF3 | CAR | FF5 |
| MKT | 0.948*** (11.91) | 0.835*** (10.57) | 0.883*** (9.857) | 0.948*** (11.91) | 0.834*** (10.57) | 0.883*** (9.861) |
| SMB | -0.325*** (-2.867) | -0.296*** (-2.719) | -0.372*** (-2.985) | -0.325*** (-2.870) | -0.296*** (-2.722) | -0.372*** (-2.986) |
| HML | -0.273** (-2.333) | -0.435*** (-3.758) | -0.112 (-0.696) | -0.271** (-2.322) | -0.433*** (-3.749) | -0.112 (-0.696) |
| RMW | | | -0.197 (-1.220) | | | -0.196 (-1.213) |
| CMA | | | -0.275 (-1.171) | | | -0.273 (-1.160) |
| MOM | | -0.409*** (-5.638) | | | -0.410*** (-5.646) | |
| Constant | -0.000667 (-0.195) | 0.00247 (0.743) | 0.000830 (0.234) | -0.000668 (-0.195) | 0.00247 (0.744) | 0.000818 (0.231) |
| R-squared | 0.314 | 0.371 | 0.319 | 0.314 | 0.371 | 0.319 |

Firstly, it is possible that we get inconclusive results because the logic behind our initial hypotheses is flawed. We reason that an increased environmental, social and governance (ESG) focus leads to divestment from vice stocks. This is assumed to lower the demand of stock, which lowers the share price, which in turn leads to undervaluation in relation to a firm's economic fundamentals. We must allow for the possibility that this reasoning is faulty. It may instead be that real demand for products and services offered by vice firms is decreasing, making such firms less profitable, depreciating share prices as a result. This would not increase the expected return of such firms. Since responsible investing principles has seen an increase in appeal during recent years, this effect can be assumed to be more pronounced the closer we get to present time.

Secondly, there is great difficulty in creating a risk factor that fully captures the differences between vice and virtue. As we mention in the introduction, what constitutes a vice and a virtue differs greatly not only across cultures, but also between individuals. It is helpful to consider a spectrum that stretches from fully vicious to fully virtuous. While some firms may be placed at either extreme, many fall somewhere in the middle. For example, it is problematic to gauge the level of vice in a firm that on one hand produces commercial aircraft, but on the other hand produces weapon systems. These inherent limitations make it difficult for us to appreciate the accuracy of our vice factor, and to measure the premium in vice stocks as well.

Another considerable limitation to our methodology is the way that we construct the vice and virtue portfolios. Firstly, the vice portfolio contains some firms that do not fit into our definition of vice, such as Netflix, Inc., Avis Budget Group, Inc., and Applied Biosystems, Inc. There are also firms that have mixed operations, such as Boeing Co.¹³ Replicating the results of our study with updated holdings, that more closely adheres to our definition of vice, is likely to generate different findings. We do maintain, however, that the portfolio is representative of our definition of vice, since these outlier firms are limited in number. Secondly, we use only healthcare and life science firms to proxy for virtue. In reality, firms from many sectors could be included in a virtue portfolio. We settle for using only the healthcare and life science industries as we regard them clear-cut cases of industries belonging to the virtuous end of the vice-virtue spectrum discussed above.¹⁴ It should

¹³ Due to time constraints, we have not adjusted the holdings accordingly.

¹⁴ Again, time constraints prevented us from constructing a more representative portfolio.

also be mentioned that healthcare firms may not always be regarded as virtuous, since profits are made from illness. A similar argument is made for the biotech sector in Fabozzi et al. (2008), who chooses to label the biotech sector as a vice industry. For future research, we suggest redoing the analysis where a more diversified virtue portfolio is constructed.

VIII. Conclusions

In this paper, we examine a 30-year period to find whether vice plays a role in determining returns of individual firms on the U.S. stock markets. By regressing a monthly vice factor against the Fama and French Three-Factor Model (FF3), Carhart Four-Factor Model (CAR), and Fama and French Five-Factor Model (FF5), we attempt to find whether effects from vice are already captured by other risk factors. We find no evidence that vice can be expected to affect stock prices, but rather, that expected effects from vice are priced by the other factors. What effect we expected vice to have on firm returns appears to be sufficiently explained by returns in the market, as well as firm-specific market capitalization, book-to-market equity, stock price momentum, operating profits, and investment policies. On the other hand, our analysis does not lead us to conclude that either the Fama and French or Carhart risk factors explain the variability in our vice factor.

By supplementing each of FF3, CAR, and FF5 with a constructed vice factor, we create augmented models used to examine whether vice stocks are associated with a premium. This is done through estimating three separate Fama and MacBeth regressions, one for each model. FF3 and FF5 generate positive premia for vice, while CAR indicates that vice has a discount. These findings prevent us from either confirming or rejecting our hypothesis of vice having a premium.

Despite not reaching any specific conclusions with regards to premia for vice stocks, we feel that our work contributes to research on the subject of vice and virtue stocks. We have laid groundwork for further discussion on the subject of pursuing both financial and non-financial goals through investing. If investors can maintain the same risk adjusted return despite divestment from certain industries, it is implied that investors can pursue non-financial goals while still achieving satisfactory returns. Furthermore, our thesis contributes to existing research within this field by

adopting performing the Fama and Macbeth analysis, by examining the entire U.S. equity market, and by adopting a long-term view, with a total of 30 years of data.

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X. Appendices

Appendix A: Description of risk factors

Below are detailed descriptions of the creation of the risk factors from the Fama and French Three-Factor Model, the Carhart Four-Factor Model, and the Fama and French Five-Factor Model.

SMB is a measure of the difference in average returns between small and big firms (market capitalization). It is created from corresponding measures where firms are sorted on different levels of firm size, book-to-market equity, operating profits, and investment policies.

$$SMB = 1/3(SMB_{(B/M)} + SMB_{(OP)} + SMB_{(INV)}),$$

where

$$SMB(B/M) = 1/3(\textit{Small Value} + \textit{Small Neutral} + \textit{Small Growth}) \\ - 1/3(\textit{Big Value} + \textit{Big Neutral} + \textit{Big Growth}),$$

$$SMB(OP) = 1/3(\textit{Small Robust} + \textit{Small Neutral} + \textit{Small Weak}) \\ - 1/3(\textit{Big Robust} + \textit{Big Neutral} + \textit{Big Weak}),$$

$$SMB(INV) = 1/3(\textit{Small Conservative} + \textit{Small Neutral} + \textit{Small Aggressive}) \\ - 1/3(\textit{Big Conservative} + \textit{Big Neutral} + \textit{Big Aggressive})$$

HML is a measure of the difference in average returns between firms with high and low book-to-market equity. High book-to-market companies are also called value stocks and low book-to-market companies are regarded as growth stocks.

$$HML = 1/2(\textit{Small Value} + \textit{Big Value}) \\ - 1/2(\textit{Small Growth} + \textit{Big Growth})$$

MOM is a measure of the difference in average returns at time between firms with positive and negative momentum. Positive momentum is defined as positive 12-month average return, while negative momentum is defined as negative 12-month average return.

$$MOM = 1/2(\textit{Small High} + \textit{Big High}) \\ - 1/2(\textit{Small Low} + \textit{Big Low})$$

RMW is a measure of the difference in average returns between firms with robust and weak operating profits, *RMW* is seen as the profitability factor.

$$RMW = 1/2(\textit{Small Robust} + \textit{Big Robust}) \\ - 1/2(\textit{Small Weak} + \textit{Big Weak})$$

CMA is a measure of the difference in average returns between firms with conservative and aggressive investment strategies.

$$CMA = 1/2(\textit{Small Conservative} + \textit{Big Conservative}) \\ - 1/2(\textit{Small Aggressive} + \textit{Big Aggressive})$$

Appendix B: Vice firms

| PERMNO | Company Name | PERMNO | Company Name |
|--------|---------------------------------|--------|----------------------------------|
| 10145 | HONEYWELL INTERNATIONAL INC | 64135 | W M S INDUSTRIES INC |
| 11891 | M G M RESORTS INTERNATIONAL | 79795 | AMERISTAR CASINOS INC |
| 12052 | GENERAL DYNAMICS CORP | 86249 | CENTRAL EUROPEAN DISTRIBUTN CORP |
| 12060 | GENERAL ELECTRIC CO | 79712 | LODGENET INTERACTIVE CORP |
| 12570 | I T T INC | 76999 | T H Q INC |
| 12623 | HUNTINGTON INGALLS INDS INC | 85838 | NEW FRONTIER MEDIA INC |
| 13267 | CAESARS ENTERTAINMENT CORP | 12140 | GOODRICH CORP |
| 13502 | ENGLITY HLDGS INC NEW | 87762 | CRYPTOLOGIC LTD |
| 13610 | OLIN CORP | 86744 | PRIVATE MEDIA GROUP INC |
| 13901 | ALTRIA GROUP INC | 76372 | INTEGRAL SYSTEMS INC |
| 13970 | TRUETT HURST INC | 84280 | L 1 IDENTITY SOLUTIONS INC |
| 14141 | SCIENCE APPLICATIONS INTL CORP | 53815 | PLAYBOY ENTERPRISES INC |
| 14252 | GAMING & LEISURE PROPERTIES INC | 76218 | PLAYBOY ENTERPRISES INC |
| 14304 | CAESARS ACQUISITION CO | 78953 | APPLIED SIGNAL TECHNOLOGY |
| 14759 | ADVANCED DRAINAGE SYSTEMS INC | 79365 | RINO INTERNATIONAL CORP |
| 15168 | VISTA OUTDOOR INC | 79641 | CONTINENTAL AIRLINES INC |
| 15331 | INTERNATIONAL GAME TECH PLC | 87005 | YOUBET COM |
| 16001 | PINNACLE ENTERTAINMENT INC NEW | 79850 | PROGRESSIVE GAMING INTL CORP |
| 16083 | TURNING POINT BRANDS INC | 15077 | U S T INC |
| 16276 | ADVANSIX INC | 27713 | APPLIED BIOSYSTEMS INC DEL |
| 16555 | UNIVERSAL CORPORATION | 59184 | ANHEUSER BUSCH COS INC |
| 16593 | NEW AGE BEVERAGES CORP | 82613 | SECURE COMPUTING CORP |
| 17523 | SPARTON CORP | 65226 | D R S TECHNOLOGIES INC |
| 17778 | BERKSHIRE HATHAWAY INC DEL | 86404 | IMPERIAL TOBACCO GROUP PLC |
| 17830 | UNITED TECHNOLOGIES CORP | 82710 | PYRAMID BREWERIES INC |
| 18091 | CURTISS WRIGHT CORP | 24046 | CLEAR CHANNEL COMMUNICATIONS INC |
| 19561 | BOEING CO | 89274 | METAL STORM LTD |
| 20512 | CACI INTERNATIONAL INC | 76090 | HARRAHS ENTERTAINMENT INC |
| 21178 | LOCKHEED MARTIN CORP | 41371 | UNITED INDUSTRIAL CORP |
| 23579 | TEXTRON INC | 77392 | POLYMEDICA CORP |
| 24766 | NORTHROP GRUMMAN CORP | 79192 | STATION CASINOS INC |
| 24942 | RAYTHEON CO | 80831 | MOVIE GALLERY INC |
| 25487 | AVIS BUDGET GROUP INC | 84616 | GUITAR CENTER INC |
| 25582 | HARRIS CORP | 75721 | ABATIX CORP |
| 29867 | ALLIANCE ONE INTERNATIONAL INC | 88279 | B A S F AG |
| 29938 | BROWN FORMAN CORP | 83189 | ARMOR HOLDINGS INC |
| 29946 | BROWN FORMAN CORP | 41444 | ABLEST INC |
| 32678 | HEICO CORP NEW | 84775 | GALLAHER GROUP PLC |
| 34497 | NATIONAL PRESTO INDS INC | 76171 | H C A INC NEW |
| 36281 | SEABOARD CORP | 80573 | KERZNER INTERNATIONAL LTD |

| | | | |
|-------|----------------------------------|-------|----------------------------------|
| 42614 | MOOG INC | 77803 | GTECH HOLDINGS CORP |
| 50788 | ESTERLINE TECHNOLOGIES CORP | 47897 | KIRIN BREWERY LTD |
| 51263 | MANITOWOC CO INC | 85213 | SCHEID VINEYARDS INC |
| 59248 | MOLSON COORS BREWING CO | 86355 | D H B INDUSTRIES INC |
| 59504 | BRITISH AMERICAN TOBACCO PLC | 87581 | ENGINEERED SUPPORT SYS INC |
| 61567 | HEXCEL CORP NEW | 53946 | STERLING CAPITAL CORP |
| 61807 | MOOG INC | 10108 | SUNGARD DATA SYSTEMS INC |
| 64899 | CONSTELLATION BRANDS INC | 86447 | CAESARS ENTERTAINMENT INC |
| 69796 | CONSTELLATION BRANDS INC | 89260 | UNITED DEFENSE INDUSTRIES INC |
| 70033 | HARLEY DAVIDSON INC | 16715 | STANDARD COMMERCIAL CORP |
| 71985 | SPARTAN MOTORS INC | 89223 | CURTISS WRIGHT CORP |
| 73219 | STURM RUGER & CO INC | 85620 | METRO GOLDWYN MAYER INC NEW |
| 75233 | VECTOR GROUP LTD | 75684 | NETEGRITY INC |
| 75828 | ELECTRONIC ARTS INC | 83563 | SWEDISH MATCH CO |
| 76138 | B E AEROSPACE INC | 86088 | BLUE RHINO CORP |
| 76477 | ORBITAL A T K INC | 89346 | TRAVELERS PPTY CASUALTY CORP NEW |
| 76592 | DIAGEO PLC | 87470 | PREMIER BANCORP INC PA |
| 77928 | COMPANIA CERVECERIAS UNIDAS S A | 79786 | ATLANTIC PREMIUM BRANDS LTD |
| 79026 | CHURCHILL DOWNS INC | 79193 | SIGNAL TECHNOLOGY CORP |
| 79338 | SCIENTIFIC GAMES CORP | 82653 | DISC GRAPHICS INC |
| 79507 | MONARCH CASINO & RESORT INC | 85927 | SECURITY ASSOCIATES INC |
| 79678 | ACTIVISION BLIZZARD INC | 52740 | COLONIAL COMMERCIAL CORP |
| 79758 | BOYD GAMING CORP | 77219 | HEALTHCARE INTEGRATED SVCS INC |
| 80563 | PENN NATIONAL GAMING INC | 81694 | GLOBAL CAPITAL PARTNERS INC |
| 80955 | WILLAMETTE VALLEY VINYDS INC | 65453 | UNITED DOMINION INDUSTRIES LTD |
| 81049 | VINA CONCHA Y TORO S A | 85658 | RAYTHEON CO |
| 82176 | CRAFT BREW ALLIANCE INC | 79640 | CONTINENTAL AIRLINES INC |
| 82515 | POOL CORP | 11522 | SUMMIT TECHNOLOGY INC |
| 82518 | RCI HOSPITALITY HOLDINGS INC | 83341 | TRAVELERS PPTY CASUALTY CORP |
| 82634 | BOSTON BEER INC | 84771 | APPLE ORTHODONTIX INC |
| 82649 | SCHWEITZER MAUDUIT INTL INC | 18374 | HONEYWELL INC |
| 83443 | BERKSHIRE HATHAWAY INC DEL | 12539 | AMERICAN BANKERS INS GROUP INC |
| 84062 | BJS RESTAURANTS INC | 80736 | ROCK BOTTOM RESTAURANTS INC |
| 84398 | SPDR S & P 500 E T F TRUST | 33312 | SUNAMERICA INC |
| 85254 | AMBEV SA | 76829 | MONEY STORE INC |
| 85488 | O S I SYSTEMS INC | 82776 | I T T CORP NEV |
| 85945 | HEICO CORP NEW | 82808 | NOR WESTER BREWING INC |
| 86021 | L 3 TECHNOLOGIES INC | 88605 | HEALTH IMAGES INC |
| 86946 | REYNOLDS AMERICAN INC | 79495 | GARMENT GRAPHICS INC |
| 87825 | UTSTARCOM HOLDINGS CORP | 65234 | DIAGNOSTIC RETRIEVAL SYS INC |
| 88392 | EMBRAER S A | 76640 | VIGORO CORP |
| 88534 | INNOVATIVE SOLUTIONS & SUPRT INC | 35529 | PRATT & LAMBERT UNITED INC |
| 88668 | MONSANTO CO NEW | 69104 | SAMSON ENERGY CO LTD PARTNERSHIP |
| 88837 | GARMIN LTD | 68208 | A O I COAL COMPANY |

| | | | |
|-------|----------------------------------|-------|-------------------------------|
| 89014 | ROCKWELL COLLINS INC | 12120 | ASSIX INTERNATIONAL INC |
| 89031 | TASER INTERNATIONAL INC | 68486 | HEALTHCARE INTERNATIONAL INC |
| 89307 | MANTECH INTERNATIONAL CORP | 75004 | ALLSTAR INNS L P |
| 89393 | NETFLIX INC | 68056 | MONARCH CAPITAL CORP |
| 58560 | AMERICAN SCIENCE & ENGR INC | 11640 | POSEIDON POOLS OF AMERICA INC |
| 42140 | PINNACLE ENTERTAINMENT INC | 69729 | M G M U A COMMUNICATIONS |
| 63830 | PRECISION CASTPARTS CORP | 66229 | AMBRIT INC |
| 87277 | MARTHA STEWART LVNG OMNIMEDIA IN | 42729 | EAGLE CLOTHES INC |
| 87816 | ROCK CREEK PHARMACEUTICALS INC | 10153 | ALLIS CHALMERS CORP |
| 45277 | INTERNATIONAL GAME TECHNOLOGY | 11843 | ALLECO INC |
| 76139 | ORBITAL SCIENCES CORP | 86450 | CATALYST ENERGY DEV CORP |
| 83529 | MULTIMEDIA GAMES HOLDING CO INC | 23421 | STEVENS J P & CO INC |
| 38149 | BALLY TECHNOLOGIES INC | 79901 | VAC TEC SYSTEMS INC |
| 78147 | M T R GAMING GROUP | 50737 | BROCKWAY INC NY |
| 10225 | BEAM INC | 60716 | SPECTRA PHYSICS INC |
| 78200 | S H F L ENTERTAINMENT INC | 19036 | BRAINTECH INC |

Appendix C: Virtue firms

| PERMNO | Company Name | PERMNO | Company Name |
|--------|-------------------------------|--------|-------------------------------|
| 10180 | AKORN INC | 75694 | BIO TECHNE CORP |
| 10200 | REPLIGEN CORP | 75860 | IMMUNOGEN INC |
| 10860 | ORASURE TECHNOLOGIES INC | 75976 | NEOGEN CORP |
| 10966 | AXOGEN INC | 76095 | HOLOGIC INC |
| 11547 | CONMED CORP | 76392 | MERIT MEDICAL SYSTEMS INC |
| 11552 | CELGENE CORP | 76591 | QUIDEL CORP |
| 11587 | ATRION CORP | 76614 | REGENERON PHARMACEUTICALS INC |
| 11600 | DENTSPLY SIRONA INC | 76661 | IONIS PHARMACEUTICALS INC |
| 11636 | HERON THERAPEUTICS INC | 76709 | I D E X X LABORATORIES INC |
| 12062 | LABORATORY CORP AMERICA HLDGS | 76736 | ALKERMES PLC |
| 12413 | ZOGENIX INC | 76744 | VERTEX PHARMACEUTICALS INC |
| 12583 | PACIRA PHARMACEUTICALS INC | 76788 | TIVITY HEALTH INC |
| 12587 | WRIGHT MEDICAL GROUP N V | 76837 | HAEMONETICS CORP MASS |
| 12622 | H C A HOLDINGS INC | 76841 | BIOGEN INC |
| 12919 | HORIZON PHARMA PLC | 77182 | PERRIGO CO PLC |
| 13105 | ACADIA HEALTHCARE CO INC | 77274 | GILEAD SCIENCES INC |
| 13107 | CLOVIS ONCOLOGY INC | 77279 | ABAXIS INC |
| 13410 | SUPERNUS PHARMACEUTICALS INC | 77447 | I C U MEDICAL INC |
| 13456 | TESARO INC | 77605 | BOSTON SCIENTIFIC CORP |
| 13543 | GLOBUS MEDICAL INC | 77629 | U S PHYSICAL THERAPY INC |
| 13621 | PUMA BIOTECHNOLOGY INC | 77649 | STERIS PLC |
| 13643 | INTERCEPT PHARMACEUTICALS INC | 77668 | EXPRESS SCRIPTS HOLDING CO |

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| 13721 | ABBVIE INC | 78034 | PATTERSON COMPANIES INC |
| 13788 | ZOETIS INC | 78081 | LIGAND PHARMACEUTICALS INC |
| 13825 | ENANTA PHARMACEUTICALS INC | 78156 | H M S HOLDINGS CORP |
| 13911 | QUINTILES TRANSNATIONAL HLDGS IN | 78756 | ORTHOFIX INTERNATIONAL N V |
| 13924 | EPIZYME INC | 78916 | ALLERGAN PLC |
| 13940 | PORTOLA PHARMACEUTICALS INC | 79637 | UNIVERSAL HEALTH SERVICES INC |
| 13947 | BLUEBIRD BIO INC | 79906 | INCYTE CORP |
| 13954 | ESPERION THERAPEUTICS INC NEW | 80539 | NEKTAR THERAPEUTICS |
| 13967 | P T C THERAPEUTICS INC | 80622 | DICKINSON HOLDING CORP |
| 14008 | AMGEN INC | 80795 | AMEDISYS INC |
| 14011 | MALLINCKRODT PLC | 81736 | RESMED INC |
| 14044 | AGIOS PHARMACEUTICALS INC | 82179 | INTEGRA LIFESCIENCES HLDNGS CORP |
| 14072 | INTREXON CORP | 82272 | MEDNAX INC |
| 14160 | FOUNDATION MEDICINE INC | 82307 | DAVITA INC |
| 14176 | ACCELERON PHARMA INC | 82508 | MYRIAD GENETICS INC |
| 14198 | ANALOGIC CORP | 82567 | OPKO HEALTH INC |
| 14238 | AERIE PHARMACEUTICALS INC | 82581 | SCHEIN HENRY INC |
| 14257 | MACROGENICS INC | 82651 | WATERS CORP |
| 14359 | XENCOR INC | 82702 | IMPAX LABORATORIES INC |
| 14432 | INTRA CELLULAR THERAPIES INC | 83111 | ALEXION PHARMACEUTICALS INC |
| 14436 | ULTRAGENYX PHARMACEUTICALS INC | 83534 | NEUROCRINE BIOSCIENCES INC |
| 14440 | RETROPHIN INC | 83950 | SPECTRUM PHARMACEUTICALS INC |
| 14459 | INOGEN INC | 84373 | QUEST DIAGNOSTICS INC |
| 14467 | REVANCE THERAPEUTICS INC | 85002 | SAREPTA THERAPEUTICS INC |
| 14674 | THERAVANCE BIOPHARMA INC | 85675 | ENVISION HEALTHCARE CORP |
| 14707 | RADIUS HEALTH INC | 86899 | LIFEPOINT HEALTH INC |
| 14763 | CATALENT INC | 87006 | UNITED THERAPEUTICS CORP |
| 14828 | SAGE THERAPEUTICS INC | 87056 | BIOMARIN PHARMACEUTICAL INC |
| 14836 | INTERSECT E N T INC | 87657 | EDWARDS LIFESCIENCES CORP |
| 14871 | LOXO ONCOLOGY INC | 87789 | LUMINEX CORP |
| 14941 | HALYARD HEALTH INC | 88159 | EXELIXIS INC |
| 14991 | ATARA BIOTHERAPEUTICS INC | 88195 | SANGAMO THERAPEUTICS INC |
| 15046 | NEVRO CORP | 88281 | CHARLES RIVER LABS INTL INC |
| 15065 | FIBROGEN INC | 88351 | INSMED INC |
| 15079 | PRA HEALTH SCIENCES INC | 88352 | INTUITIVE SURGICAL INC |
| 15183 | SPARK THERAPEUTICS INC | 88421 | ARENA PHARMACEUTICALS INC |
| 15222 | LION BIOTECHNOLOGIES INC | 88436 | ENDO INTERNATIONAL PLC |
| 15284 | BLUEPRINT MEDICINES CORP | 88446 | ILLUMINA INC |
| 15454 | GLAUKOS CORP | 88504 | BRUKER CORP |
| 15585 | TELADOC INC | 88545 | MEDICINES COMPANY |
| 15630 | AIMMUNE THERAPEUTICS INC | 88790 | ARRAY BIOPHARMA INC |
| 15638 | GLOBAL BLOOD THERAPEUTICS INC | 88845 | AETNA INC NEW |
| 15694 | PENUMBRA INC | 88860 | ALIGN TECHNOLOGY INC |
| 15779 | CYTOMX THERAPEUTICS INC | 88863 | EXACT SCIENCES CORP |

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| 15788 | MYOKARDIA INC | 88949 | SEATTLE GENETICS INC |
| 15789 | NOVOCURE LTD | 89036 | NATUS MEDICAL INC |
| 15934 | AVEXIS INC | 89070 | ZIMMER BIOMET HOLDINGS INC |
| 15937 | EDITAS MEDICINE INC | 89110 | OMNICELL INC |
| 16386 | IRHYTHM TECHNOLOGIES INC | 89179 | ANTHEM INC |
| 16543 | VAREX IMAGING CORP | 89269 | CENTENE CORP DEL |
| 16562 | ANAPTYSBIO INC | 89781 | MOLINA HEALTHCARE INC |
| 19393 | BRISTOL MYERS SQUIBB CO | 90011 | MAGELLAN HEALTH INC |
| 20482 | ABBOTT LABORATORIES | 90029 | DYNAVAX TECHNOLOGIES CORP |
| 21936 | PFIZER INC | 90125 | CORCEPT THERAPEUTICS INC |
| 22111 | JOHNSON & JOHNSON | 90177 | ACADIA PHARMACEUTICALS |
| 22752 | MERCK & CO INC NEW | 90178 | ALNYLAM PHARMACEUTICALS INC |
| 22825 | CANTEL MEDICAL CORP | 90188 | NUVASIVE INC |
| 27043 | VARIAN MEDICAL SYSTEMS INC | 90233 | MOMENTA PHARMACEUTICALS INC |
| 27887 | BAXTER INTERNATIONAL INC | 90272 | WELLCARE HEALTH PLANS INC |
| 39642 | BECTON DICKINSON & CO | 90423 | THERAVANCE INC |
| 41292 | HEALTHCARE SERVICES GROUP INC | 90436 | HALOZYME THERAPEUTICS INC |
| 43757 | IMMUNOMEDICS INC | 90564 | PRESTIGE BRANDS HOLDINGS INC |
| 44329 | TELEFLEX INC | 90664 | DEXCOM INC |
| 48653 | HUMANA INC | 90734 | L H C GROUP |
| 50876 | LILLY ELI & CO | 90957 | NXSTAGE MEDICAL INC |
| 52337 | TENET HEALTHCARE CORP | 90988 | BROOKDALE SENIOR LIVING INC |
| 52716 | HILL ROM HOLDINGS INC | 91086 | ACORDA THERAPEUTICS INC |
| 60097 | MEDTRONIC PLC | 91571 | EMERGENT BIOSOLUTIONS INC |
| 60186 | OWENS & MINOR INC NEW | 92040 | AMICUS THERAPEUTICS INC |
| 61508 | BIO RAD LABORATORIES INC | 92050 | INSULET CORP |
| 62092 | THERMO FISHER SCIENTIFIC INC | 92096 | JAZZ PHARMACEUTICALS PLC |
| 62498 | WEST PHARMACEUTICAL SERVICES INC | 92220 | MASIMO CORP |
| 64186 | CIGNA CORP | 92432 | ENSIGN GROUP INC |
| 65541 | COOPER COMPANIES INC | 92587 | BIOTELEMETRY INC |
| 69550 | MYLAN N V | 92655 | UNITEDHEALTH GROUP INC |
| 73139 | STRYKER CORP | 93035 | SELECT MEDICAL HOLDINGS CORP |
| 75107 | ABIOMED INC | 93264 | IRONWOOD PHARMACEUTICALS INC |