UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

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

AUTHORS: *Anton Johansson, Christian Persson*

TUTOR: *Marcin Zamojski, Ph.D.*

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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 focus[2] 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 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):

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

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

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \epsilon_{t,}$$

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

$$R_t = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + \epsilon_{t,}$$

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 momentum[5] 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 time[7]. 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 returns[8] 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 ±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
MKT	0.0059	0.0024	0.0116	0.0445	2.8888	-0.9669	0.3459	-0.2324	0.1135	348
SMB	0.0011	0.0016	0.0005	0.0306	5.2959	0.4569	0.3408	-0.1533	0.1875	348
HML	0.0023	0.0016	0	0.0293	2.8176	0.123	0.24	-0.111	0.129	348
MOM	0.0055	0.0025	0.0064	0.0474	11.4067	-1.5602	0.5272	-0.3439	0.1833	348
RMW	0.0034	0.0014	0.003	0.0266	11.6502	-0.4506	0.3257	-0.1906	0.1351	348
CMA	0.0028	0.0011	0.0012	0.0205	2.3894	0.5167	0.1644	-0.0688	0.0956	348
RF	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 weighting[9], 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.

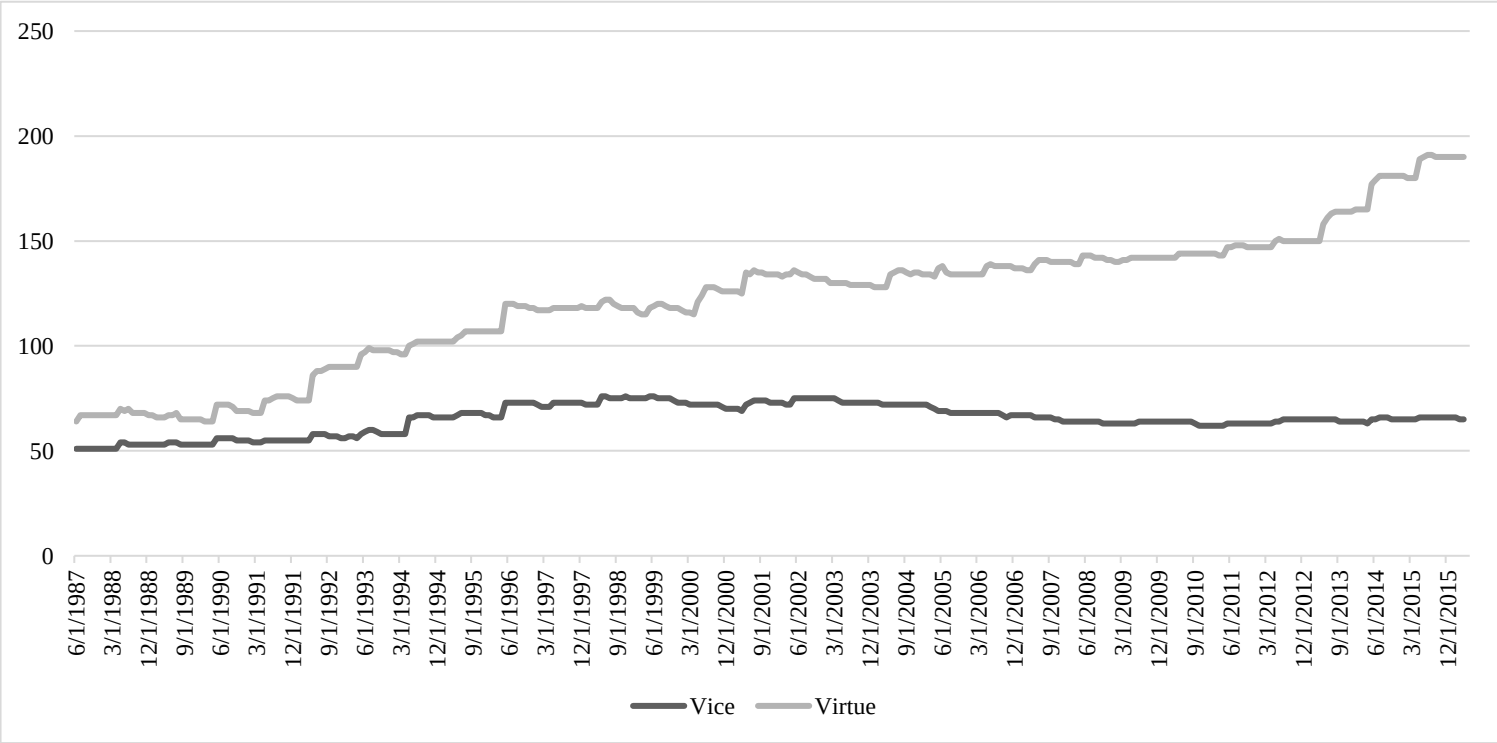

Table 3

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:

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

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

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

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**
MKT	0.0588	0.0507	0.105***
	(1.58)	(1.32)	(2.60)
SMB	-0.131**	-0.129**	-0.0004
	(-2.45)	(-2.40)	(-0.01)
HML	0.514***	0.502***	0.465***
	(9.21)	(8.72)	(6.28)
RMW			0.386***
			(5.30)
CMA			-0.0991
			(-0.93)
MOM		-0.0297	
		(-0.84)	
Constant	0.0002	0.0005	-0.0011
	(0.14)	(0.28)	(-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.

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

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**
MKT	0.0008	0.0008	0.0013
SMB	0.0006	0.0000	-0.0040
HML	0.0008	0.0024	-0.0015
MOM		0.0065	
RMW			0.0056
CMA			-0.0010
VICE	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***	0.835***	0.883***	0.948***	0.834***	0.883***
	(11.91)	(10.57)	(9.857)	(11.91)	(10.57)	(9.861)
SMB	-0.325***	-0.296***	-0.372***	-0.325***	-0.296***	-0.372***
	(-2.867)	(-2.719)	(-2.985)	(-2.870)	(-2.722)	(-2.986)
HML	-0.273**	-0.435***	-0.112	-0.271**	-0.433***	-0.112
	(-2.333)	(-3.758)	(-0.696)	(-2.322)	(-3.749)	(-0.696)
RMW			-0.197			-0.196
			(-1.220)			(-1.213)
CMA			-0.275			-0.273
			(-1.171)			(-1.160)
MOM		-0.409***			-0.410***	
		(-5.638)			(-5.646)	
Constant	-0.000667	0.00247	0.000830	-0.000668	0.00247	0.000818
	(-0.195)	(0.743)	(0.234)	(-0.195)	(0.744)	(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 Carhar 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.

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

where

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

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

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

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.

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

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.

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

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.

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

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

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

Appendix B: Vice firms

PERMNO	Company Name
10145	HONEYWELL INTERNATIONAL INC
11891	M G M RESORTS INTERNATIONAL
12052	GENERAL DYNAMICS CORP
12060	GENERAL ELECTRIC CO
12570	I T T INC
12623	HUNTINGTON INGALLS INDS INC
13267	CAESARS ENTERTAINMENT CORP
13502	ENGILITY HLDGS INC NEW
13610	OLIN CORP
13901	ALTRIA GROUP INC
13970	TRUETT HURST INC
14141	SCIENCE APPLICATIONS INTL CORP
14252	GAMING & LEISURE PROPERTIES INC
14304	CAESARS ACQUISITION CO
14759	ADVANCED DRAINAGE SYSTEMS INC
15168	VISTA OUTDOOR INC
15331	INTERNATIONAL GAME TECH PLC
16001	PINNACLE ENTERTAINMENT INC NEW
16083	TURNING POINT BRANDS INC
16276	ADVANSIX INC
16555	UNIVERSAL CORPORATION
16593	NEW AGE BEVERAGES CORP
17523	SPARTON CORP
17778	BERKSHIRE HATHAWAY INC DEL
17830	UNITED TECHNOLOGIES CORP
18091	CURTISS WRIGHT CORP
19561	BOEING CO
20512	CACI INTERNATIONAL INC
21178	LOCKHEED MARTIN CORP
23579	TEXTRON INC
24766	NORTHROP GRUMMAN CORP
24942	RAYTHEON CO
25487	AVIS BUDGET GROUP INC
25582	HARRIS CORP
29867	ALLIANCE ONE INTERNATIONAL INC
29938	BROWN FORMAN CORP
29946	BROWN FORMAN CORP
32678	HEICO CORP NEW
34497	NATIONAL PRESTO INDS INC
36281	SEABOARD CORP

PERMNO	Company Name
64135	W M S INDUSTRIES INC
79795	AMERISTAR CASINOS INC
86249	CENTRAL EUROPEAN DISTRIBUTN CORP
79712	LODGENET INTERACTIVE CORP
76999	T H Q INC
85838	NEW FRONTIER MEDIA INC
12140	GOODRICH CORP
87762	CRYPTOLOGIC LTD
86744	PRIVATE MEDIA GROUP INC
76372	INTEGRAL SYSTEMS INC
84280	L 1 IDENTITY SOLUTIONS INC
53815	PLAYBOY ENTERPRISES INC
76218	PLAYBOY ENTERPRISES INC
78953	APPLIED SIGNAL TECHNOLOGY
79365	RINO INTERNATIONAL CORP
79641	CONTINENTAL AIRLINES INC
87005	YOUBET COM
79850	PROGRESSIVE GAMING INTL CORP
15077	U S T INC
27713	APPLIED BIOSYSTEMS INC DEL
59184	ANHEUSER BUSCH COS INC
82613	SECURE COMPUTING CORP
65226	D R S TECHNOLOGIES INC
86404	IMPERIAL TOBACCO GROUP PLC
82710	PYRAMID BREWERIES INC
24046	CLEAR CHANNEL COMMUNICATIONS INC
89274	METAL STORM LTD
76090	HARRAHS ENTERTAINMENT INC
41371	UNITED INDUSTRIAL CORP
77392	POLYMEDICA CORP
79192	STATION CASINOS INC
80831	MOVIE GALLERY INC
84616	GUITAR CENTER INC
75721	ABATIX CORP
88279	B A S F AG
83189	ARMOR HOLDINGS INC
41444	ABLEST INC
84775	GALLAHER GROUP PLC
76171	H C A INC NEW
80573	KERZNER INTERNATIONAL LTD

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

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

Appendix C: Virtue firms

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

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

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