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Intangible Assets and US Stock Returns: An analysis using the Index Method, Panel Regression, and Machine Learning

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Abstract. This study examines the impact of intangible assets on stock returns in the U.S. using the Drucker Institute indices, which assess companies based on customer satisfaction, employee engagement and development, innovation, social responsibility, and financial stability. The relevance of this study lies in the growing importance of considering non-financial indicators in investment decision-making. The objective is to determine how these indices affect stock returns across different sectors. The hypotheses posit that each index has a positive impact. The study employs both panel regression with fixed effects and machine learning methods using XGBoost with Shapley values to analyze data from U.S. companies for the period from June 30, 2016, to June 30, 2023. The results indicate that social responsibility has a broadly positive impact on stock returns across various sectors. Innovation significantly affects returns only in the technology sector. Customer satisfaction and financial stability exhibit varying effects depending on the sector, while employee engagement and development show only negative impacts in the energy sector. The significance of this research lies in its contribution to understanding the role of intangible assets in shaping stock performance. We show that investors can achieve both ethical satisfaction and higher financial returns by prioritizing investments in companies with strong social responsibility records. Additionally, we draw the attention of investors and researchers to the importance of considering sectoral affiliation when analyzing companies. The use of advanced analytical tools, such as XGBoost with Shapley values, underscores the potential of machine learning in uncovering complex relationships in financial data. This approach proves to be highly promising for future research.

Key words: Drucker Institute Indexes; stock returns; ESG; corporate social responsibility; machine learning.

JEL G11, G17, C33, C58

1. Introduction

In recent years, investors have increasingly focused on the non-financial aspects of companies when making investment decisions [1]. Funds oriented towards ESG investments are gaining popularity [2]. High ESG indicators at the country level contribute to sustainable and long-term economic growth and increased citizen [3].

The literature on stakeholder theory indicates that corporate social responsibility (CSR) initiatives can help companies improve their relationship with various stakeholder groups [4]. From the perspective of resource theory, CSR can be used to create sustainable competitive advantage for the firm. Indeed, a company's reputation and image are valuable and rare intangible assets [5]. Within the principal-agent theory framework, active engagement in ESG activities can help reduce agency costs, information asymmetry, and increase company transparency [6]. High ESG scores for a company can reduce its

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risks [7], cost of debt [8], and cost of equity capital [9].

Not only ESG and CSR, but also other non-financial indicators have a positive impact on company's financial characteristics. For instance, high customer satisfaction leads to repeat purchases, recommendations, and positive reviews, resulting in improved financial performance [10].

On the other hand, it is the employees who, by receiving salaries and benefits, create value for the company and satisfy customers' needs [11]. Therefore, employee engagement is a crucial factor and has a significant impact on the company's financial performance [12].

Another important factor for the success of a company is its ability to generate and implement innovations. Innovative companies are persistently more profitable than non-innovators, according to studies by Geroski et al. [13], and Love et al. [14]. New products often temporarily provide an advantage over competitors, allowing for profit generation. Moreover, companies adept at implementing multiple innovations can consistently outperform others, as shown by Roberts [15], and Love et al. [14].

There are numerous ratings attempting to evaluate the non-financial characteristics of companies and various aspects of their operations [16]. A recent study by Crosby & Ghanbarpour [17] analyzed the Drucker intangibles measurement system and concluded its potential for academic research. Drucker Institute Company Ranking is compiled based on 34 indicators from various sources. It assesses companies based on characteristics such as Customer Satisfaction, Employee Engagement and Development, Innovation, Social Responsibility, and Financial Strength.

The purpose of this study is to examine the impact of intangible assets, measured by Drucker Institute indices, on the stock returns of US companies. To the best of our knowledge, this is the first research to apply the Drucker Institute Company Ranking for this purpose. Additionally, the study aims to demonstrate the use of machine learning and Shapley values to analyze data and identify key factors affecting returns.

The research hypotheses suggest that higher indices assessing a company's intangible assets and financial strength are associated with higher stock returns:

H1: Customer satisfaction index positively impacts companies' stock profitability.

H2: Employee engagement and development index positively affect companies' stock profitability.

H3: Innovation index positively influences companies' stock profitability.

H4: Social responsibility index positively affects companies' stock profitability.

H5: Financial strength index positively impacts companies' stock profitability.

Structure of the article. Section 2 provides a review of previous research, while Section 3 describes the data and methodology. In Section 4, we first present the results obtained through panel regression for each sector, followed by the results derived from machine learning. Section 5 is dedicated to the discussion. The final section draws conclusions and offers recommendations.

2. Literature review

Using the data from the Drucker Institute Company Ranking, Ghanbarpour et al. [18] and Ratigan & Zaleski [19] studies have found significant influence of these rankings' indicators on Tobin's Q. However, Ratigan & Zaleski [19] note the ambiguity of the impact of these indicators on companies from different sectors. Thus, a preferable approach seems to be considering the sectoral affiliation of companies.

2.1. Customer Satisfaction

High levels of customer satisfaction contribute to loyalty, protect current market share from competitors, and enhance the company's reputation. Additionally, it leads to a reduction in the cost of capital [20]. Luo et al. [21] found that companies with higher customer satisfaction receive higher growth potential ratings for their stocks from analysts.

Fornell et al. [22] discovered that high customer satisfaction positively impacts stock returns partly because companies with high customer satisfaction often show positive earnings surprises. Malshe et al. [23] indicate that customer satisfaction positively affects stock returns through its negative impact on short interest. Wei et al. [24] show that high customer satisfaction can mitigate the negative impact of corporate social irresponsibility on financial performance. Peng et al. [25] demonstrated that investments in companies with high levels of customer satisfaction can yield higher returns than the market benchmark index.

On the other hand, Ittner et al. [26] found a positive impact of customer satisfaction only on short-term stock returns, with no significant effect on long-term returns.

Jacobson & Mizik [27] believe that the pricing anomaly is not due to the financial markets' systematic inability to reflect the financial consequences of customer satisfaction in the current stock price, but rather due to the abnormal returns achieved by a small group of satisfaction leaders in the computer and internet sectors during the learning period.

2.2. Employee Engagement and Development

Engaged employees not only enhance labor productivity but also contribute to business sustainability, making a significant contribution to achieving the company's goals. Additionally, loyal employees are inclined to actively defend the organization's interests, thereby strengthening its reputation [28]. Employee development programs make a substantial positive contribution to organizational efficiency [29]. Chi & Gursoy [30] found no significant impact of employee satisfaction on the financial performance of companies in the hotel industry.

Nevertheless, Boustanifar & Kang [31] found that companies with better treatment of their employees demonstrate higher stock returns.

However, according to agency theory, if managers implement extensive employee welfare plans in an effort to deter employees from exposing managerial misconduct, improved employee welfare might actually correlate with increased crash risk. The study by Ben-Nasr & Ghouma [32] provides evidence that high levels of employee welfare standards contribute to stock price crash risk.

2.3. Innovation

Innovations are crucial for the growth and development of businesses and represent a way to achieve competitiveness in the market [33]. Both technological and managerial innovations positively impact company productivity [34]. Innovations significantly contribute to increasing company profitability [13]. Companies with a Corporate Innovation Strategy are less susceptible to stock price crashes [35].

Ortega-Argilés et al. [36] demonstrated that investments in R&D have a more positive impact on the productivity of high-tech companies specifically. Coad & Rao [37] found that innovations have a significant positive impact on the growth of high-tech companies.

Dranev et al. [38] further discovered that when fintech companies engage in M&A, firms with higher R&D expenditures exhibit greater abnormal stock re-

turns. Therefore, there is particular interest in studying the influence of this indicator on stock returns in the technology sector.

2.4. Social Responsibility

A high ESG rating reduces company risks and decreases the cost of debt [39]. Shanaev & Ghimire [40] found that changes in ESG ratings significantly impact short-term stock returns, with rating upgrades leading to increased returns and downgrades leading to decreased returns. Liu et al. [41] showed that a company's ESG rating had a consistent positive correlation with stock returns during the Covid-19 crisis. These results support the view that ESG efforts help firms improve their social image and public trust, which is crucial for financial stability, especially during economic downturns when public trust in corporations and capital markets unexpectedly declines. Given their high public trust, investors may demand more stocks with high ESG ratings during a crisis.

However, Liu et al. [41] also found a negative correlation between corporate social ratings and stock returns during "normal" times. This result may be due to companies focusing more on social responsibility and sustainable practices, which could entail higher costs or investments that temporarily affect their profitability.

The study by Feng et al. [42] shows that, in the long term, CSR positively impacts stock returns, while ESG negatively impacts them. However, the authors conclude that in the short term, a higher ESG rating can significantly boost stock returns.

Finally, Dorfleitner et al. [43] found that companies with high levels of CSR exhibit higher stock returns, explaining this by the fact that such companies more frequently receive unexpected additional cash flows.

2.5. Financial Strength

The examination of the impact of financial indicators on stock returns is not the primary focus of our research. However, we decided to include the Financial Strength indicator calculated by the Drucker Institute as one of the potential determinants of stock returns**.**

Traditionally, analysts evaluate companies using Return on Capital (ROC), Return on Invested Capital (ROIC), and Return on Equity (ROE) as measures of company performance [44]. Rheynaldi et al. [45] found a significant positive influence of Return on Assets (ROA) on stock returns. Another popular metric for measuring value creation by a company is Economic Value Added (EVA) [46].

On the other hand, De Wet & Du Toit [47] point out that the impact of Return on Equity (ROE) and Economic Value Added (EVA) on stock returns is very low.

2.6. Machine learning method

Studies by Gu et al. [48] and Teplova et al. [49] demonstrate that applying machine learning methods to market data can be a highly effective and valuable approach. While machine learning (ML) presents a flexible and scalable alternative to econometric benchmark models, its primary drawback lies in being characterized as a black box approach. In other words, ML often lacks inherent explainability, making it challenging to elucidate causalities between explanatory and target variables.

The approach we use was proposed by Berger [50]. It involves combining machine learning (ML) and Shapley values, which allows us to understand which indicators play a key role in forecasting. Like the author of this study, we use Boosted Trees as the ML method.

2.7. Degree of development of the problem

The study of intangible assets and their impact on various company characteristics has garnered significant attention from both academics and practitioners. Key aspects such as customer satisfaction, employee

engagement, innovation, and social responsibility are regarded as important non-financial indicators that can influence a company's financial performance and stock returns. However, existing research often presents conflicting conclusions.

For example, high levels of customer satisfaction have been linked to increased stock returns, as shown by Luo et al. [21] and Fornell et al. [22]. Nonetheless, some studies, such as Ittner et al. [26], suggest that this effect is short-lived. Additionally, Jacobson & Mizik [27] argue that this positive impact is observed only in a small number of stocks.

Research on employee engagement and development also presents mixed results. Boustanifar & Kang [31] found that companies with better employee treatment demonstrate higher stock returns. However, Ben-Nasr & Ghouma [32] provide evidence that high levels of employee welfare standards can contribute to stock price crash risk.

On the contrary, studies on the impact of innovations indicate only positive effects. For instance, Jia [35] found that companies with a corporate innovation strategy are less prone to stock price declines.

The relationship between CSR and ESG practices and stock returns is also subject to varying interpretations. Shanaev & Ghimire [40] and Feng et al. [42] report that higher ESG ratings generally correlate with positive short-term stock returns. However, Fiskerstrand et al. (2020) did not find such an impact, and Feng et al. [42] assess the long-term influence of ESG as negative, while CSR is seen as positive.

A unique feature of our study is the use of comprehensive indicators calculated by the Drucker Institute, which draw on various sources to provide a holistic assessment. The study period from 2016 to 2023 covers significant market events, including the COVID-19 pandemic, the market downturn due to rising interest rates in 2022, and several periods of market growth. This extended timeframe allows us to draw comprehensive conclusions about the impact of these indicators on company stock returns.

3. Data and Methods

3.1. Data

Data from companies in the US stock market are used for the period from June 30, 2016, to June 30, 2023. The reporting date chosen is June 30 of each year, which is the date Drucker Institute Company Ranking is published. Stock returns for the following year are chosen as the dependent variable. Table 1 presents the description of the variables.

Table 2 presents the descriptive statistics; the data sample is balanced and contains no missing values.

Table 3 presents the correlation matrix for all variables used in the study.

Table 1. **Description of Variables**

Variable	Description
Customer Satisfaction	The Drucker Institute calculates based on the American Customer Satisfaction Index; CSRHub: Product Rating; J. D. Power: Net Promoter Score; J. D. Power: Customer Satisfaction Index; wRatings: Quality Score.
Employee Engagement and Development	The Drucker Institute calculates based on the Burning Glass Institute, Harvard Business School, and Schultz Family Foundation: American Opportunity Index; CSRHub: Comp & Benefits Rating; Glassdoor: Culture & Values Rating, Career Opportunities Rating, Compensation & Benefits Rating; Glassdoor engagement metrics: Overall Rating, Recommend Rating; Glassdoor confidence metrics: CEO Rating, Positive Business Outlook Rating; Indeed: Work Wellbeing; Payscale: Pay Differential; Payscale: Job Satisfaction.

End of table 1

Variable	Description
Innovation	The Drucker Institute is calculated based on Lightcast: Cutting-edge Job Postings (Relative); Lightcast: R&D Job Postings (Relative); Clarivate: Number of Inventions (Relative); Clarivate: Rate of Patent Abandonment (Relative); Clarivate: Trademark Applications (Relative); Clarivate: Trademark Registers (Relative); Clarivate: R&D Expenditures (Relative); Boston Consulting Group and Fast Company: American Innovation Index; Professor Dimitris Papanikolaou of Northwestern University and Professor Amit Seru of Stanford University: Patent Value (Relative); Supply Chain Resource Cooperative: Innovation Rating; wRatings Innovation Index.
Social Responsibility	The Drucker Institute is calculated based on CSRHub: Overall ESG Score (Absolute); CSRHub: Overall ESG Score (Relative); HIP Investor: Overall ESG Rating; HIP Investor: SDG Rating; HIP Investor's Vision Rating; Supply Chain Resource Cooperative: Social Responsibility Rating; Sustainalytics: Management Score (Absolute); Sustainalytics: Management Score (Relative).
Financial Strength	The Drucker Institute is calculated based on ISS EVA: Economic Profit metrics (Economic Value Added, EVA Spread, EVA Margin, EVA Momentum by Capital, EVA Momentum by Sales); Refinitiv Eikon: Accounting Profit metrics (Operating return on invested capital, Return on assets, Return on common equity, Earnings for common shareholders); Refinitiv Eikon: Share of Market; Refinitiv Eikon: Three-Year Average Total Shareholder Return
P/B	Price/ book value ratio
LNMcap	Natural logarithm of market capitalization
Momentum	Stock return over the past year
RETURN	Stock return for the next year starting June 30th.

Table 2. **Descriptive Statistics**

Variable	Number of Observations	Mean	Max	Min	Standard Deviation
Customer Satisfaction	3234	50.3981	79.4000	15.0000	9.4698
Employee Engagement and Development	3234	50.6125	82.0000	0.0000	9.9852
Innovation	3234	50.4401	212.3000	34.3000	10.7058
Social Responsibility	3234	50.8230	78.9000	27.2000	10.1352
Financial Strength	3234	50.7552	106.7000	14.6000	9.8417
P/B	3234	3.7628	13.0000	0.1049	3.5022
LNMcap	3234	23.4494	28.3956	17.5683	1.3519
Momentum	3234	0.1257	1.1600	-0.9704	0.3812
RETURN	3234	0.1214	1.1600	-0.9290	0.3798

Table 3. **Correlation Matrix**

Customer Satisfaction	Employee Engagement and Development	Innovation	Social Responsibility	Financial Strength	P/B	LNMcap	Momentum	RETURN	
1.000	0.190	0.245	0.381	0.165	0.144	0.166	0.049	0.001	Customer Satisfaction
	1.000	0.275	0.402	0.262	0.182	0.463	0.065	0.004	Employee Engagement and Development
		1.000	0.408	0.359	0.135	0.534	–0.002	0.004	Innovation
			1.000	0.240	0.066	0.481	–0.019	–0.022	Social Responsibility
				1.000	0.285	0.495	0.200	–0.001	Financial Strength
					1.000	0.334	0.159	–0.123	P/B
						1.000	0.184	–0.137	LNMcap
							1.000	–0.306	Momentum
								1.000	RETURN

3.2. Methodology

Two approaches were used to assess the impact of Drucker Institute indices on stock returns: panel regression and machine learning.

3.2.1. Panel regression

Using tests for differences in constants across groups, the Breusch-Pagan test, and the Hausman test, it was found that the model with fixed effects is the most suitable.

For each sector, a panel regression of the following form was constructed:

$$Return_{it} = \alpha_i + \beta_1 Drucker_{it} + \\ + \beta_2 PB_{it} + \beta_3 Momentum_{it} + \\ + \beta_4 LNMcap_{it} + \varepsilon_{it}, \quad (1)$$

Where *Return* — the stock return for the next year, *Drucker* — the Drucker Institute Company indexes, *PB* — the Price/Book value multiplier, *Momentum* — the stock return for the previous year (Momentum factor), and *LNMcap* — the natural logarithm of market capitalization.

3.2.2. Machine learning

The study utilizes XGBoost (eXtreme Gradient Boosting) — a machine learning algorithm that employs gradient boosting to construct an ensemble of decision trees. The approach is extensively described by Chen & Guestrin [51] and Berger [50]. It operates by sequentially adding trees to the model, each correcting the errors of the previous one, thus minimizing the loss function. Let $\hat{y}_i^{(t-1)}$ be the prediction of the i-th instance at the t-th iteration, we need to add f_t in order to minimize the following objective:

$$obj^t = \sum_{i=1}^{n} l\left(y_i, \hat{y}_i^{(t-1)} + f_t\left(x_i\right)\right) + \\ + \Omega\left(f_t\right). \quad (2)$$

Additionally, the study employs Shapley values — a method for interpreting machine learning models that explains the model's predictions by computing the contribution of each feature to the outcome.

As outlined by Lundberg & Lee [52], Shapley values, originating from game theory, represent the singular model-agnostic framework in interpretable machine learning that adheres to statistical properties like efficiency, symmetry, and additivity.

According to Berger [50], the Shapley value ϕ_j of j-th explanatory variable can be defined as follows:

$$\phi_j = \sum_{S \subseteq \{1,\ldots,p\}/\{j\}} \frac{|S|!\left(p-|S|-1\right)!}{p!} \times \times \left(f_{S\cup\{j\}}\left(x_{S\cup\{j\}}\right) - f_S\left(x_S\right)\right). \quad (3)$$

With x_S as a subset of the explanatory variables in the set S, $f_{S\cup\{j\}}$ is the trained model with explanatory variable j and f_S without.

In the study, Shapley values are used in conjunction with XGBoost to understand the importance of each feature in forecasting, enabling the analysis of which factors have the greatest impact on model outcomes. Shapley values compute the importance of each feature by considering its influence on predictions for each observation. Once Shapley values are computed, they can be used to interpret the model's forecasts. It is possible to visualize the contribution of each feature to the forecast for a specific observation or aggregate Shapley values to assess the overall importance of features in the model. This helps understand which factors have the most influence on XGBoost model predictions.

Positive Shapley values for a specific indicator indicate that it positively impacts the forecast, while negative values indicate the opposite. Large absolute Shapley values indicate that the feature strongly influences the model's forecast for a given observation.

For training, 70 % of the dataset is utilized, while 30 % serves as the test dataset. The same data used for panel regression is applied, but with the addition of dummy variables for sectors. This approach is akin to Ghanbarpour et al. [18], where the authors assessed the impact of Drucker Institute indices on Tobin's Q for the entire sample of companies.

4. Results

4.1. Panel regression

The White test showed the absence of heteroskedasticity, while the VIF (variance inflation factor) test indicated no multicollinearity. In Table 4, the results for US companies from 11 sectors are presented. Table 5 shows which hypotheses were confirmed and in which sectors, using panel regression.

Customer Satisfaction has a significant negative impact on stock returns in the Basic Materials, Consumer Cyclical, and Consumer Defensive sectors, while it has a positive impact in Energy and Industrials sectors. Ratigan & Zaleski [19] also found positive effects of this indicator on Tobin's Q in these sectors, while negative effects were observed in Real Estate and Utilities. The absence of a positive impact is consistent with the findings of the previous study by Peng et al. [25].

Employee Engagement and Development does not have a significant impact in any of the sectors, except for Energy, where it has a negative influence. Ratigan & Zaleski [19] did not find any significant association of this indicator with Tobin's Q. The negative impact of this indicator aligns with the findings of Ben-Nasr & Ghouma [32], who found that high levels of employee welfare standards may lead to stock price crash risk.

Table 4. **Results of panel regression using a fixed effects model for each sector**

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Healthcare	Industrials	Real Estate	Technology	Utilities
Number of Observations	155	136	534	250	154	376	348	508	130	480	163
LSDV R-squared	0.48	0.54	0.45	0.55	0.69	0.54	0.52	0.57	0.67	0.49	0.54
Variables	Coefficient (Standard Error)										
Const	25,3802 (4,2992)***	18,7121 (4,8041)***	12,2336 (1,8393)***	22,2586 (2,5674)***	21,2311 (3,0562)***	25,5539 (2,1804)***	10,8034 (2,50566)***	12,9647 (2,0315)***	18,7888 (3,2128)***	9,3536 (1,9858)***	14,8414 (3,1002)***
Customer Satisfaction	–0,0097 (0,0052)*	–0,0011 (0,0060)	–0,0068 (0,0034)**	–0,0056 (0,0027)**	0,0097 (0,0039)**	–0,0005 (0,0031)	0,0019 (0,0027)	0,0067 (0,0024)***	–0,0001 (0,0034)	0,0003 (0,0029)	0,0044 (0,0033)
Employee Engagement and Development	0,0009 (0,0085)	–0,0122 (0,0083)	–0,0058 (0,0041)	0,0025 (0,0046)	–0,0101 (0,0044)**	–0,0004 (0,0041)	0,0033 (0,0043)	0,0044 (0,0031)	0,0028 (0,0037)	–0,0007 (0,0043)	–0,0021 (0,0018)
Innovation	0,0071 (0,0081)	–0,0025 (0,0066)	–0,0017 (0,0039)	0,0071 (0,0044)	–0,0003 (0,0065)	–0,0002 (0,0031)	0,0037 (0,0038)	0,0025 (0,0041)	0,0028 (0,0034)	0,0097 (0,0036)***	0,0044 (0,0031)
Social Responsibility	0,0324 (0,0131)**	0,0163 (0,0111)	0,0102 (0,0052)*	0,0174 (0,0061)***	0,0021 (0,0088)	0,0005 (0,0049)	0,0039 (0,0043)	0,0151 (0,0043)***	0,0063 (0,0069)	0,0055 (0,0061)	0,0101 (0,0056)*
Financial Strength	0,0118 (0,0063)*	0,0089 (0,0057)	0,0058 (0,0035)*	0,0036 (0,0038)	–0,0053 (0,00389)	0,0088 (0,0028)***	0,0041 (0,0023)*	0,0049 (0,0035)	0,0112 (0,0054)**	–0,0057 (0,0026)**	0,0024 (0,0038)
P/B	0,1492 (0,0674)**	–0,0525 (0,0457)	0,0102 (0,0213)	0,0997 (0,0277)***	0,0351 (0,0665)	0,1198 (0,0294)***	–0,0503 (0,0246)**	0,0282 (0,0247)	0,0034 (0,0502)	–0,0173 (0,0193)	0,0266 (0,0489)
LNMcap	–1,2014 (0,1962)***	–0,7777 (0,2034)***	–0,5366 (0,0841)***	–1,0142 (0,1161)***	–0,8961 (0,1273)***	–1,1057 (0,0966)***	–0,4698 (0,1103)***	–0,6321 (0,0938)***	–0,8414 (0,1428)***	–0,3996 (0,0869)***	–0,6661 (0,1363)***
Momentum	0,1453 (0,1051)	0,0291 (0,1110)	–0,2601 (0,0506)***	–0,0157 (0,0651)	0,1349 (0,0743)*	–0,0905 (0,0505)*	–0,0956 (0,0519)*	–0,3018 (0,0452)***	–0,0884 (0,0811)	–0,2188 (0,0454)***	–0,0893 (0,0813)

Table 5. **Hypotheses confirmed through panel regression**

Hypotheses	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Healthcare	Industrials	Real Estate	Technology	Utilities
H1: Customer satisfaction index positively impacts companies' stock profitability.					+			+			
H2: Employee engagement and development index positively affect companies' stock profitability.											
H3: Innovation index positively influences companies' stock profitability.										+	
H4: Social responsibility index positively affects companies' stock profitability.	+		+	+				+			+
H5: Financial strength index positively impacts companies' stock profitability.	+		+			+	+		+		
Note: The symbol «+» indicates that the hypothesis was confirmed in the respective sector.											

Innovation positively influences returns only in the Technology sector. This aligns with the findings of Dranev et al. [38] for fintech companies. This also aligns with the conclusions of Coad & Rao [37] and Ortega-Argilés et al. [36] regarding the importance of R&D expenditures and innovations for high-tech companies.

Social Responsibility positively influences stock returns of companies in Basic Materials, Consumer Cyclical, Consumer Defensive, Industrials, and Utilities sectors. This differs from the findings of Ratigan & Zaleski [19], who found only a negative association in the Consumer Cyclical sector. However, it aligns with the conclusions of other researchers regarding the impact of ESG and CSR on stock returns, such as Shanaev & Ghimire [40] and Dorfleitner et al. [43].

Financial Strength has a positive impact in the Basic Materials, Consumer Cyclical, Financial Services, Healthcare, and Real Estate sectors, and a negative im-

pact in the Technology sector. Ratigan & Zaleski [19] found the same positive influence, but only on Tobin's Q.

The *P/B* ratio positively influences the returns of companies in the Basic Materials, Consumer Defensive, and Financial Services sectors, and negatively influences those in healthcare.

It is interesting to note the presence of a size effect in all sectors, where the natural logarithm of capitalization significantly negatively influences returns. This aligns with the findings of Van Dijk [53].

On the other hand, previous returns (Momentum) have a negative impact in Consumer Cyclical, Financial Services, Healthcare, Industrials, and Technology sectors, and a positive impact in the Energy sector.

4.2. Machine learning

The figure 1 displays Shapley values for all observations:

To identify the most significant factors, the median value of the absolute Shapley values is calculated. As seen in Figure 2, factors with values above 0.01 include Momentum, Financial Strength, P/B, and Social Responsibility. The model has an R^2 of 0.1945.

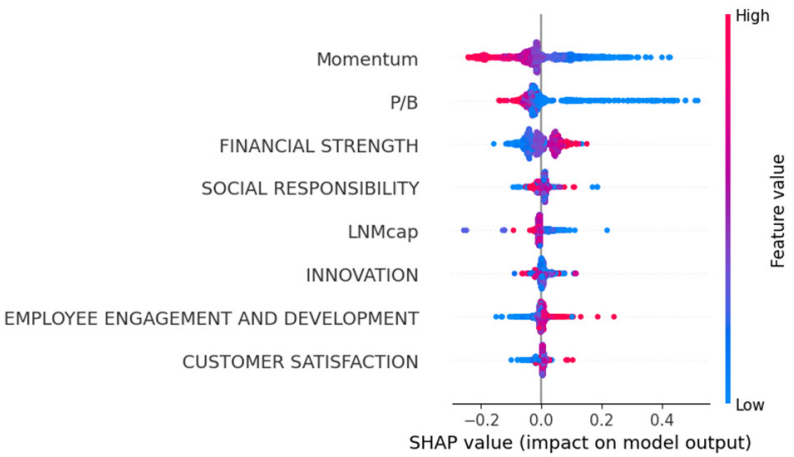

Figure 1. Shapley values

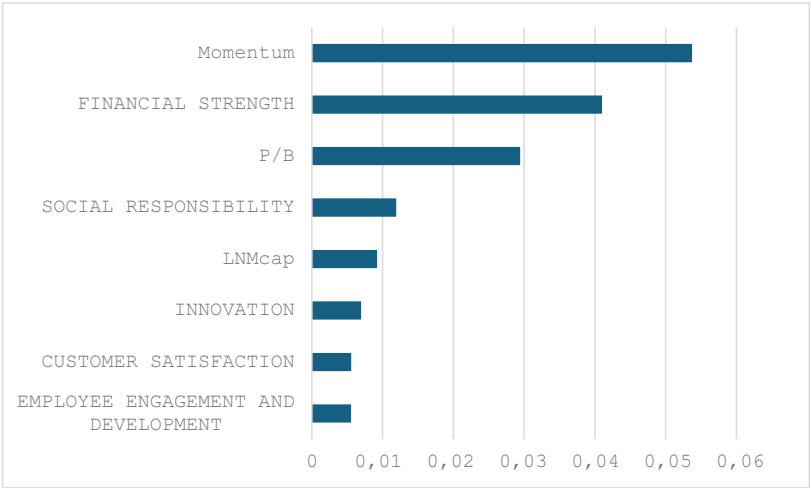

Figure 2. Median value of the absolute Shapley values

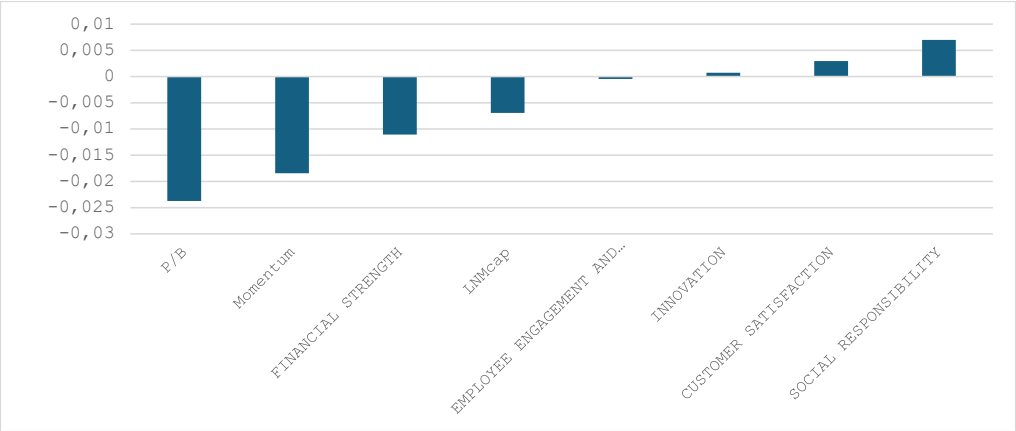

Figure 3. Median Values of Shapley Values

Figure 3 presents the median Shapley values. This allows us to understand the direction of influence. For instance, Momentum and P/B negatively impact returns. Regarding Momentum, this aligns with the conclusions drawn from panel regression, where negative influence was identified for 5 sectors and only positive for one. Conversely, the significant negative impact of *P/B* is intriguing, as panel regression indicates a positive influence in three sectors and negative in only one. Nonetheless, such an influence aligns with the findings of Fama & French [54].

Financial Strength negatively affects returns. However, as observed from Figure 1, there exists a significant group of observations for which the impact is clearly positive, consistent with the conclusions drawn from panel regression about the ambiguous influence of this indicator.

Social Responsibility positively impacts returns, which is fully consistent with the conclusions drawn from panel regression. Thus, for the entire sample, only hypothesis 4 was confirmed using machine learning. This aligns with the findings of earlier studies, such as those by Dorfleitner et al. [43] and Shanaev & Ghimire [40].

5. Discussion

The results of our study confirm that intangible assets, as measured by the Drucker Institute indices, have a significant impact on the stock returns of U.S. companies. The hypotheses suggesting that intangible assets positively affect stock returns were partially confirmed.

The only hypothesis that was unequivocally confirmed by both machine learning and panel regression is Hypothesis 4, which states that social responsibility positively influences stock returns. This effect can be explained by the fact that companies with high levels of social responsibility more frequently receive unexpected additional cash flows, as described by Dorfleitner et al. [43], and perform more sustainably during crises, as indicated by Liu et al. [41].

The remaining hypotheses were confirmed only by panel regression for certain sectors. For example, Customer Satisfaction had a mixed effect, being positive for some sectors and negative for others. In contrast, the innovation index had a positive effect only in the technology sector. This can be attributed to the fact that companies in this sector rely more on innovative products and processes to maintain their competitiveness and growth. Innovation is one of the key drivers of development in high-tech industries. R&D activities help improve the productivity of high-tech companies, according to Ortega-Argilés et al. [36].

The Employee Engagement and Development index had a negative impact only for companies in the Energy sector. It is possible that companies in this sector are more prone to the effect described by Ben-Nasr & Ghouma [32], where managers may offer excessively generous benefits to employees to distract them from important issues. This behavior can lead to the accumulation of negative news until a tipping point, when bad news is released to the market and causes stock prices to crash.

The Financial Strength index had a positive impact on companies in 5 out of 11 sectors but a negative impact on those in the technology sector. This can be attributed to the fact that investors in the technology sector are more focused on future growth prospects rather than current financial performance. Low current financial metrics may be due to the significant investments made by these companies. A similar phenomenon of investors prioritizing future financial outcomes is described by De Wet & Du Toit [47].

This study, while providing substantial insights into the impact of Drucker Institute indices on stock returns, has several limitations.

Firstly, the dataset is limited to companies included in the Drucker Institute indices. Although these companies represent a large portion of the U.S. stock market capitalization, the conclusions drawn may not be applicable to smaller companies.

Secondly, investor behavior varies significantly across different markets, suggesting that these findings may be specific to the U.S. market.

Finally, these conclusions are relevant to recent years but may not necessarily apply to earlier periods. These limitations offer opportunities for further research to broaden the temporal and geographical scope of the analysis.

6. Conclusion

The Drucker Institute offers a remarkably valuable set of indices for evaluating the intangible assets of companies. Researchers can utilize these indices for a broad spectrum of studies, including exploring the relationships between financial and non-financial characteristics of firms. In our research, these indices are employed for the first time to analyze the impact of intangible assets on stock returns, enriching the body of knowledge regarding stock return determinants and highlighting the significance of intangible assets as a key corporate attribute.

Our results demonstrate that the determinants of stock returns differ markedly across various sectors. Consequently, it is crucial for both investors and academic researchers to consider sector-specific nuances in their analyses to make more substantiated conclusions and develop effective investment strategies.

We found that the innovation index positively influences stock returns only in the technology sector. This underscores the necessity for management in this sector to allocate resources to research and development (R&D) initiatives and integrate innovations into their business processes, thereby driving high returns for investors.

Financial Strength and Customer Satisfaction exhibit significant but differing effects across various sectors. This emphasizes the need for investors to handle these indicators with care and to thoroughly examine the unique attributes of each sector.

The Employee Engagement and Development index has a negative impact on stock returns only in the Energy sector. This effect requires further investigation.

Among the non-financial indicators examined, social responsibility stands out as the factor exerting the most widespread and consistently positive influence on stock returns. For academic researchers, this finding highlights the importance

of including this indicator in analytical models as both significant and essential. Practically, this observation suggests that investors can achieve both ethical satisfaction and higher financial returns by prioritizing investments in companies with strong social responsibility records. For corporate managers, it reinforces the value of investing in socially responsible initiatives as a strategic approach to enhance shareholder value and attract socially conscious investors.

The use of XGBoost combined with Shapley values in our study provides a powerful analytical tool for identifying and understanding the relationships between various indicators. This method offers a valuable alternative to traditional regression analysis and holds great potential for future research.

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Нематериальные активы и доходность акций США: анализ с использованием индексного метода, панельной регрессии и машинного обучения

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Аннотация. В данном исследовании изучается влияние нематериальных активов на доходность акций США с использованием индексов Института Друкера, которые оценивают компании на основе удовлетворенности клиентов, вовлеченности и развития сотрудников, инноваций, социальной ответственности и финансовой устойчивости. Актуальность этого исследования заключается в растущей важности учета нефинансовых показателей в принятии инвестиционных решений. Цель исследования в том, чтобы определить, как данные индексы влияют на доходность акций в разных секторах. Гипотезы утверждают, что каждый индекс влияет положительно. В исследовании используются как панельная регрессия с фиксированными эффектами, так и методы машинного обучения с использованием XGBoost со значениями Шепли для анализа данных компаний США за период с 30 июня 2016 г. по 30 июня 2023 г. Результаты анализа указывают на то, что социальная ответственность оказывает широкое положительное влияние на доходность акций в разных секторах. Инновации существенно влияют на доходность только в технологическом секторе. Удовлетворенность клиентов и финансовая устойчивость оказывают различные эффекты в зависимости от сектора, в то время как вовлеченность и развитие сотрудников показали только отрицательное влияние в энергетическом секторе. Значимость этого исследования заключается в его вкладе в понимание роли нематериальных активов в формировании результативности акций компаний. Мы показываем, что инвесторы могут достичь как этического удовлетворения, так и более высоких финансовых доходов, приоритизируя инвестиции в компании с сильными показателями социальной ответственности. Помимо этого, обращаем внимание инвесторов и исследователей на важность учета секторальной принадлежности компаний при анализе. Использование передовых аналитических инструментов, таких как XGBoost со значениями Шепли, подчеркивает потенциал машинного обучения для выяснения сложных взаимосвязей в финансовых данных. Этот подход показывает себя как крайне перспективный для будущих исследований.

Ключевые слова: индексы Drucker Institute; доходность акций; ESG; корпоративная социальная ответственность; машинное обучение.

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