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Does Intellectual Capital Affect the Volatility of Returns? An Empirical Investigation on Italian Listed Companies

[1]Brett W. Cantrell, [2]Daniela Coluccia, [2]Stefano Fontana and [2]Silvia Solimene

[1]*E.H. Patterson School of Accountancy, University of Mississippi, USA*
[2]*University of Rome Sapienza, Rome, Italy*

Abstract: In modern information economies, economic success increasingly depends on the ability to apply knowledge and to transform it into firm value. While intellectual capital plays a critical role in firm success, it is an intangible asset that is difficult to measure and that is unrecorded by the firm. Difficulties in measuring intellectual capital, as well as the dynamic nature of the firms that rely on it, may lead to greater stock market volatility/risk. Consistent with this expectation, in statistical tests we find that intellectual capital, measured by VAIC, positively relates to the volatility of stock returns section among Italian listed companies. We find this positive relation for two components of a firm's risk: systematic risk and specific risk. The finding is relevant to both investors concerned with understanding the risk/reward balance of particular investments and regulators concerned with market stability.

Keywords: Intellectual Capital, VAIC, Stock Price Volatility, Systematic Risk, Idiosyncratic Risk, Financial Markets

Introduction

Through time different factors have driven economic success, from economies built on land ownership to industrial capital to managerial capital. In the present era of information economics, economic success depends greatly on the ability to apply knowledge and to transform it into firm value (Zanda, 2012; Nuryaman, 2015). The intellectual capital associated with the key processes of capturing and applying information, while critical to success, is not reflected financial reporting. Thus, accounting systems suffer a serious disconnect with value in capital markets. This study examines how intangible intellectual capital relates to an important capital market construct, volatility. Specifically, the study examines how a firm's intellectual capital (measured with the Value Added Intellectual Coeffcient [VAIC]) relates to market volatility in the IFRS context.

The stock market plays a vital role in economic allocation of resources (Junkin, 2012), allowing companies to acquire capital easily and efficiently. Stock market price volatility is one of the most important aspects of financial markets, as it influences portfolio management, option pricing and market regulation (Poon and Granger, 2003). This study fills a gap in the extant literature by examining how systematic and idiosyncratic risk relate to intellectual capital for Italian listed firms on the Italian Stock Exchange. In Italy, listed companies must adopt IAS 38 when accounting for intangible assets. However, intellectual capital is an unrecorded intangible asset linked to structural, relational, human and stakeholder capabilities and relations. Thus, intellectual capital drives the economic performance of firm but is not recognized as an asset.

Given the significance of intellectual capital on the economics of a firm, we expect intellectual capital as measured by VAIC to explain price volatility beyond traditional market determinants and accounting determinants of price volatility. Specifically, we expect that firms with greater levels of intellectual capital experience greater stock price volatility, both relative to the market (beta) and idiosyncratically (standard deviation). Firms that rely on intellectual capital may experience greater return volatility because measuring intellectual capital is challenging (Volkov, 2012; Petty and Guthrie, 2000) and uncertainty in the value of intellectual capital creates uncertainty in the markets. Similarly, Lev (2000) notes that intangible assets are generally higher risk than physical or financial assets. Finally, increases in the dynamism and speed of information flows associated with knowledge economies (and intellectual capital) can lead to higher idiosyncratic risk/volatility (Campbell *et al.*, 2001).

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We gather data from three years, 2006, 2011 and 2016, to reflect three different economic moments: before financial crisis (2006); during the sovereign European debt crisis (2011); and after the crisis (2016) as well as after the introduction of Quantitative Easing (QE) by the European Central Bank. Consistent with our predictions, we find that higher levels of intellectual capital measured by VAIC correlate to greater market risk/volatility (beta) and to greater idiosyncratic risk/volatility (standard deviation).

Understanding the relation between intellectual capital and price volatility will be useful to investors concerned with the risks inherent in their investments, as well as, market regulators concerned with market stability. This study also contributes to the academic literature, by providing the first evidence of the relation between VAIC and a critical market characteristic. While previous literature mainly focuses on the relationship between intellectual capital and firm performance/value (Tudor *et al.*, 2014; Sumedrea, 2013; Poraghajan *et al.*, 2013; Maditinos *et al.*, 2011), we provide the first evidence of VAIC's relation to price volatility. This finding enriches investors' understanding of valuation creation from intellectual capital as value must be understood in the context of the risks taken to achieve it. Finally, given the limitations of Tobin's q to capture and explain the value of intellectual capital (Pamela and Mark, 1993), we build on recent literature that relates intellectual capital (measured by VAIC) to Tobin's q (Hejazi *et al.*, 2016; Alshubiri, 2015) by relating VAIC to market measures of risk. Nuryaman (2012) considers market performance measures better than financial performance measures in depicting the value of intellectual capital elements. Thus, market based measures of risk should correspond to a firm's capabilities in converting resources into profits (including the capabilities around intellectual capital) and investors' perceptions of the firm.

The remainder of the paper is organized as follows: the first section summarizes the prior intellectual capital literature and the components of volatility of firms. Then a section formally states our hypothesis. Next, there are explained data and methodology employed. Following a section reports empirical results and finally a conclusion section.

Literature Review

Intellectual Capital

As the global economy has evolved into a knowledge-based economy, intangible assets have been widely recognized as the driving force of an economy's productivity growth and have become more and more crucial for a firm's survival and prosperity (Martinez-Torres, 2006). Increasingly firms primarily rely on knowledge and intellectual capital rather than physical and financial resources (Stewart, 1997; Hayton, 2005). Wu *et al.* (2006) claim that intellectual capital has replaced physical and financial resources. Goldfinger (1997) suggests that the source of economic value and wealth is no longer the production of material goods but the creation and manipulation of intangible assets. Research has shown that firm value in the knowledge economy lies largely in IC rather than production and sales (Sullivan and Sullivan, 2000). Additionally, IC does not decrease in value with usage (Kong, 2008).

The increasing importance of intellectual capital, as a strategic asset capable of generating a sustainable competitive advantage over time, leads to the need for an acceptable measurement model, as traditional financial tools do not capture the relevant intellectual capital concepts (Volkov, 2012; Sullivan and Sullivan, 2000). In fact, in the IC field it is commonly understood that traditional financial measurement systems are inadequate for today's businesses (Pulic 2004). However, a review of the literature on intellectual capital shows that measuring intellectual capital is difficult and challenging.

In response to the increase in importance of intellectual capital and a desire to understand its role in corporate growth and value creation, researchers face two key challenges: (1) adequately defining intellectual capital and (2) measuring the contribution of intellectual capital to firm value.

Some have proposed defining intellectual capital as the entire difference between the market value and the book value of the equity of a firm (a sort of unidentifiable goodwill, according to Lev and Zarowin, 1999; Stewart, 1997; Sveiby, 1997; Salchi *et al.*, 2014). Nunamaker *et al.* (2002) define IC as the knowledge acquired and utilized by organizations, which is held in the minds of its members, embodied in its procedures and processes and stored in its digital and non-digital media.

Others see intellectual capital as the sum of elements/components, which should be identified and measured separately. In keeping with this perspective, in recent years intellectual capital has been integrated by adding several new components to the traditional mixture of human capital, structural capital and relational capital (Bontis, 1998; Edvinsson and Malone, 1997). Based on this new interpretation, intellectual capital can be regarded as a set of knowledge assets that are acquired and controlled by the business and are the important mechanism for value creation (Alipour, 2012).

A more detailed consideration might include other dimensions of intellectual capital, such as renewal capital (Kianto *et al.*, 2010), entrepreneurial capital (Erikson, 2002) and trust capital (Mayer *et al.*, 1995). Schiuma and Lerro (2008) and Cassiman and Veugelers (2006) define intellectual capital broadly as the sum of components: human, structural, organizational, social and stakeholder capital.

As for the second challenge of measuring intellectual capital, several models have been proposed by past literature. Brennan (2001) summarizes the prevailing intellectual capital models. One such model simply measures the difference between the book value and the market value of a company. This approach relies on the market to adequately understand and collectively value intellectual capital, an assumption that is hampered by difficult to evaluate "hidden" intangible assets. A second model, the "Skandia Navigator System" (Edvinsson, 1997) decomposes intellectual capital into five key dimensions of the business (1. Financial; 2. Client; 3. Human; 4. Processes; 5. Renewal and Development). A third approach, developed by Roos *et al.* (1997) also develops an IC-Index across several dimensions. More recently, Appuhami and Bhuyan (2015) note that three models of intellectual capital rise to prominence: the market to book value ratio (M/B), Tobin's q (Bontis, 1998) and value added intellectual coefficient (VAIC) (Pulic, 2000). VAIC values intellectual capital by calculating and combining various ratios of financial profitability to resources, thus the VAIC indicator ccan measure the real value of a company and its future abilities. VAIC has become the most used intellectual capital measure in the literature over the last decade (Volkov, 2012). Other methods to value intellectual capital include Economic Value Added (EVA) and the Balanced Score Card (BSC). Pulic (2004) argues that EVA focus on the efficiency of just one resource, capital employed and therefore this method can not be a valid measuring system for the new economy. The descriptive nature of the BSC and the lack of comparability in the non-monetary indicators that is favors, make BSC an in adequate valuation method for intellectual capital (Daum, 2002).

The shift to a knowledge-based economy severs the link between the cost of intangible asset and the value it generates. VAIC focuses on the creation of value from intellectual capital from three different types of inputs: physical and financial capital, human capital and structural capital (Firer and Williams, 2003; Pulic, 2000). This notion of value has outperformed typical financial metrics, such as ROI and ROE, especially when estimating the creation and destruction of value over time.

With VAIC as a starting point, several papers have further developed the VAIC measure (Volkov, 2012). Chen *et al.* (2004) examine the relationship between the various components of intellectual capital. Wang and Chang (2005) implemented this model of value by adding the relationship between the components of intellectual capital and the performance of the enterprise (Volkov, 2012), thus highlighting the sensitivity of the company's success with the VAIC and the competitive advantage that comes from it. Laing *et al.* (2010) further extend the Pulic model by documenting the contribution to the growth in intellectual capital. Following prior literature we use the VAIC measure to proxy for the value of intellectual capital in this study.

Stock Price Volatility

Stock price volatility is a well known proxy for the perceived risk by investors. It is also an indicator of changes in trends in the market place. Engle (1982) finds that information serves as an important cause of volatility, which can affect or alter the expected return on asset. Volatility rises also in presence of modifications in macroeconomic policies, which can increase uncertainty among investors. Volatility is a statistical measure of the dispersion of returns for a given security or market index, which can either be measured by using the standard deviation or variance between returns from that same security or market index. Commonly, the higher the volatility, the riskier the security.

One measure of the relative volatility of a particular stock to the market is its beta. A beta approximates the overall volatility of a security's returns against the returns of a relevant benchmark (usually the S&P 500). In finance, the beta (β or beta coefficient) of an investment indicates whether the investment is more or less volatile than the market as a whole. In general, a beta less than 1 indicates that the investment is less volatile than the market, while a beta more than 1 indicates that the investment is more volatile than the market. Volatility is measured as the fluctuation of the price around the mean: the standard deviation. Beta is important because it measures the risk of an investment that cannot be reduced by diversification. It does not measure the risk of an investment held on a stand-alone basis, but the amount of risk the investment adds to an already-diversified portfolio. In the capital asset pricing model, beta risk is the only kind of risk for which investors should receive an expected return higher than the risk-free rate of interest (Fama, 1976). "Changes in a company's stock price may be partly attributable to a set of macroeconomic variables, such as changes in interest rates, inflation and national productivity, which are common factors because they affect the prices of most stocks in that market. These items are considered market risk components" (Sällebrant *et al.*, 2007, p. 1472).

In finance, volatility (σ) is the degree of variation of a trading price series over time as measured by the standard deviation of logarithmic returns. Historic volatility is derived from the time series of past market prices. An implied volatility is derived from the market price of a market traded derivative (in particular an option). It measures the unsystematic risk, also known as idiosyncratic risk or diversifiable risk, on a portfolio of assets. Unsystematic risk is the risk associated with individual assets, which (unlike market risk) can be diversified away to smaller levels by including a greater number of assets in the portfolio (specific risks "average

out"). "Changes in stock price may be affected by the firm's success and performance, which include items like new product innovations, cost-cutting efforts, a disastrous fire at a manufacturing plant, or the discovery of an illegal corporate act. These components of return are considered firm-specific or idiosyncratic components because they affect only that firm and not the returns of other investments stocks in the market" (Sällebrant *et al.*, 2007, p. 1473).

According to the Modern Portfolio Theory (MPT) by Markowitz (1952), investors are risk adverse, meaning that given two portfolios that offer the same expected return, investors will prefer the less risky one. Thus, an investor will take on increased risk only if compensated by higher expected returns. Conversely, an investor who wants higher expected returns must accept more risk. The exact trade-off will be the same for all investors, but different investors will evaluate the trade-off differently based on individual risk aversion characteristics. The implication is that a rational investor will not invest in a portfolio if a second portfolio exists with a more favorable risk-expected return profile – i.e., if for that level of risk an alternative portfolio exists that has better expected returns. Investors can reduce their exposure to individual asset risk by holding a diversified portfolio of assets. Diversification may allow for the same portfolio expected return with reduced risk. The portfolio's risk is a complicated function of the variances of each asset and the correlations of each pair of assets. To calculate the risk of a four-asset portfolio, an investor needs each of the four assets' variances and six correlation values, since there are six possible two-asset combinations with four assets. Because of the asset correlations, the total portfolio risk, or standard deviation, is lower than what would be calculated by a weighted sum.

From a managerial and accounting perspective, stock return volatility at a firm level is important to managers, since volatility affects the cost of capital. Volatility is also critical to shareholders as they must understand the risks inherent in their investments to ensure a proper balance between risk and reward. The real concern to investors is the systematic risk, In fact, investors get rewarded for bearing systematic risk. It is not total variance that affects expected returns, but only that part of the variance in returns that cannot be diversified away (Sällebrant *et al.*, 2007).

Hypothesis Development

The finance and economics literature also explores with the linkages between intellectual capital and both profitability and the stock market (Tudor *et al.*, 2014; Sumedrea, 2013; Poraghajan *et al.*, 2013; Maditinos *et al.*, 2011). For example, Daniel and Titman (2006) show that stock returns on markets are not linked to past financial performance of past years but to intangible information

about future returns. However, prior literature provides little evidence around the relation between intellectual capital and stock market volatility. Sällebrant *et al.* (2007) conduct a small sample analysis using an adjusted intellectual capital rating based on firm's disclosures. The authors show that disclosure transparency around intellectual capital reduces idiosyncratic risk but increases systematic risk. This study adds to the literature by examining the relation between measures of intellectual capital (VAIC) and stock market volatility (beta and standard deviation of returns).

Campbell *et al.* (2001) demonstrates that while aggregate market and industry variances have been stable (updating and confirming Schwert's 1989 finding that market volatility did not increase in the period 1926/1997), firm level variance displays a large and significant positive trend, actually doubling between 1962 and 1997. The authors claim that this increase relates to the impact of the information technology revolution and the increasing speed of information flows. Additionally, Mazzucato and Tancioni (2007; 2012) show that industries in periods of dynamic innovation experience greater market volatility. If information economies where success is driven by intellectual capital are more dynamic we would expect the extent of a firms' reliance on intellectual capital to be associated with greater market volatility.

Additionally, as discussed in literature review section, intellectual capital is difficult to measure and not reflected in traditional reporting systems (Sullivan and Sullivan, 2000). Lev (2000, p. 42) notes that "the level of risk associated with intangibles is, in general, substantially higher than that associated with most physical and financial assets." While firms with high intellectual capital are more likely to succeed in converting resources in profits, the increase in the information complexity of this intangible asset increases the difficulty in making financial forecasts. Information asymmetry generally leads to greater volatility (Coluccia *et al.*, 2017). Thus, the uncertainty around the value of intellectual capital could drive volatility in stock prices.

For these reasons, we formally state the following hypothesis:

> *H1: Firms with higher levels of intellectual capital will experience greater stock market volatility. Abbreviations and Acronyms*

Data and Methodology

Sample Selection

We collected financial and market variables from three years, 2006, 2011 and 2016, to reflect three different economic moments: before financial crisis (2006); during the sovereign European debt crisis

(2011); and after the crisis (2016) as well as after the introduction of Quantitative Easing (QE) by the European Central Bank. We collect this information for a homogenous sample composed of industrial companies from Italian Stock Exchange in Milan.

We excluded financial intermediaries, insurance companies and football clubs because of their different financial reporting standard sets. We also excluded companies listed after 12/31/2006 and those in the process of delisting during the period 1/1/2017-12/31/2016. We also eliminated several companies for which the documents were not available for the periods in question. Thus, we obtained a sample of 130 firms with 390 firm-year observations. We chose a homogeneous and balanced panel of firm to understand their behavior in terms of risk exposure and VAIC over the period 2006, 2011 and 2016.

Variable Measurement

The dependent variable in our statistical tests, volatility or risk is measured both by the beta factor (Sharpe, 1964) which represents the non-diversifiable risk (also known as systematic risk or market risk) and by the standard deviation of stock price (as specific or idiosyncratic risk at a firm level). This is to say that the variance of a security includes both systematic and specific portion of risk, the sum also known as "Total Risk" (Elton *et al.*, 2003; Goyal and Santa Clara, 2003). Both measures are well established in the finance literature with higher values corresponding to riskier securities.

Specifically, Beta is estimated each year as the regression coefficient of the stock's return on the market's return along the previous two years. We calculate the standard deviation of stock returns on weekly equity returns in years 2006 and 2016.

The critical independent variable of interest in our tests is the VAIC measure developed by Pulic (2000) and used extensively in the intellectual capital literature. The VAIC measure is derived from the firm's financial accounting and thus serves as a more objective measure than indices developed from discretionary disclosures. In the present paper, we estimate VAIC by applying Pulic's *formula*:

$$VAIC = ICE + CEE$$

Where:
$VAIC$ = The value of intellectual coefficient
ICE = The intellectual capital efficiency coefficient (estimated by the difference between HCE [human capital efficiency coefficient] and SCE [structural capital efficiency coefficient]);
CEE = The capital employed efficiency coefficient.

Statistical Model

To test our hypothesis, we performed a multivariate regression analysis by relating the dependent variables (beta or standard deviation) to the explanatory variables identified below. The regression can, therefore, be summarized in the following multivariate model:

$$Beta = a + \beta_1 VAIC + \beta_2 ROE + \beta_3 Lev + \beta_4 LNA + \beta_5 TQ + \beta_6 Age + \beta_7 DOL + \varepsilon \quad (1)$$

$$St.Dev. = a + \beta_1 VAIC + \beta_2 ROE + \beta_3 Lev + \beta_4 LNA + \beta_5 TQ + \beta_6 Age + \beta_7 DOL + \varepsilon \quad (2)$$

Where:
$Beta$ = The market risk
$Std. Dev.$ = The specific risk
$VAIC$ = The value added intellectual coefficient
ROE = The return on equity
Lev = The leverage (financial debt/equity)
LNA = The natural logarithm of total assets
TQ = Tobin's Q; Age is the firm age estimated as the number of years since listing
DOL = The degree of operating leverage

Before carrying out the regressions, we verified the possible multicollinearity between explanatory variables using the Variance Inflation Factor (VIF). In addition, we used the robust standard error clustered at the firm level (HAC). The regressions were performed using the OLS model. The Breusch-Pagan test attested that this model is preferable to the random effects panel model and the Hausman test attested that the panel model was preferable to random effects with regard to the fixed-effects panel model.

As noted, VAIC is the variable of interest for the study. A significant and positive coefficient estimate for β_1 in both equation (1) and (2) would provide support for our hypothesis that firms with higher intellectual capital will experience greater stock market volatility. In each model we also include a set of control variables identified in the prior literature as related to stock market volatility, either beta or the standard deviation of stock returns or both. For consistency, we include the same controls in each model. Table 1 lists the independent variables in the models with predicted signs.

Wei and Zhang (2006) show that ROE negatively relates to stock return volatility. Thus, firms with stronger financial performance experience less volatility in the market. We also control for leverage as firms with higher leverage should experience greater volatility (for a given level of asset risk) under the Modigliani-Miller Theory (1961). However, empirical investigations into the relation between leverage and volatility provide mixed results (Christie, 1982; Wei and Zhang, 2006; Brandt *et al.*, 2010; Bartram *et al.*, 2015).

Table 1: Variables used in empirical models

Explanatory variables	Symbol	Measurement	Exp. Sign
Value Added of Intellectual Coefficient	VAIC	ICE + CEE	+
Economic Performance	ROE	Return on Equity	-
Financial Situation	LEV	Financial debts/Equity	+
Firm's Age	A	Age at the date of 31/12	-
Degree of Operating Leverage	DOL	% change in EBIT/% change in sales	+
Firm size	LNA	LN Total Assets	-
UnRecorded intangible assets	TQ	(market value of equity+liabilities)/(total assets)	+

The natural logarithm of the firm's total assets is included to control for the size of the firm, as larger firms have less systematic and firm specific risk (Binder, 1992; Cheng and Ng, 1992; Wong, 1995). We include Tobin's Q as a control for unrecorded intangible assets other than intellectual capital. Lev (2000) and Kothari *et al.* (2002) both note that intangible assets increase information asymmetry and thus magnify volatility and variability of firm value. Thus, we expect a significant and positive coefficient estimate on Tobin's Q. We also control for the age of the firm as older firms with longer histories of reported performance have on average less information asymmetry and volatility (Fama and French, 1989; Chincarini *et al.*, 2016). Thus, we expect a negative relation between age and volatility.

Finally, we control for the degree of operating leverage (DOL). Operating leverage is the effect of fixed costs on the variability of earnings before interest and taxes (EBIT). In other words, it is the responsiveness of the firm's EBIT to fluctuations in sales. Following Damodaran, (2014) we calculate DOL as:

$$\frac{\% \ change \ in \ EBIT}{\% \ change \ in \ sales}$$

Higher values of DOL imply that a firm's profits will vary more greatly due to a given percentage change in sales. Thus, operating leverage correlates to greater volatility in earnings and thus stock returns. This positive relation between has operating leverage and volatility has been documented in the prior literature (Lev, 1974; Myers, 1977; Turnbull, 1977; Gahlon and Gentry, 1982; Mandelker and Ghon Rhee, 1984).

Empirical Results

Descriptive Statistics

Table 2 reports descriptive statistics on the variables used in the study for each of the three years used to construct the sample. Firm size of companies in our sample (measured by natural logarithm of total assets) appears stable across the three years. The average levels of both VAIC and Tobin's Q have decreased over the time;

this means that probably both the level of intangible assets recognized and the intangible assets not recognized but perceived by financial market have had a decrease. The average level of leverage grew in 2011 as the result of the financial crisis and stabilized by 2016. Similarly, the ROE, albeit always positive, shows the lowest result in 2011. Regarding the dependent variables, the average level of standard deviation remains stable from 2006 to 2011 then decreases in 2016, while beta shows a parabolic trend with the highest average level in 2011.

Multivariate Analysis

In this section, we estimate regression Equations (1) and (2) to analyze the effect of VAIC on volatility. Table 3 reports the regression results of Equation (1) where Beta is regressed on VAIC and controls. The high R^2 value (0.482) supports the goodness of fit of the proposed model. In addition, the small difference between the R^2 and the adjusted R^2 values demonstrates the adequacy of the number of explanatory variables considered. Lastly, the P-values (F) attest to the significance of the models as a whole (i.e., all variables simultaneously).

As shown in Table 3, all control variables exhibit estimated coefficients in the predicted directions with all but one being statistically significant. More critically for this study, the estimated coefficient on VAIC is positive and statistically significant with a value of 0.0049 (p-value≤0.05), consistent with our hypothesis. The finding supports the hypothesis that firms with greater values of intellectual capital experience more volatility relative to the market benchmark (i.e. more systematic risk).

Table 4 reports the regression results of Equation (2) where the standard deviation of stock returns is regressed on VAIC and controls. Again the model exhibits a high R^2 (0.391), a small difference between the R^2 and the adjusted R^2 values and highly significant P-values (F). Lev, LNA and Tobin's Q continue to be statistically significant in the predicted directions. ROE and DOL are no longer significant in this model suggesting that they correlate with systematic risk but not idiosyncratic risk. However, now the coefficient estimate on Age is significantly negative as predicted. Most importantly, the coefficient estimate on VAIC continues to be positive (0.0158) and statistically significant (p-value ≤ 0.01).

Table 2: Descriptive statistics

Var.	Mean	Median	Min	Max	Std. Dev.	Skew.	Kurt.
Panel A: Descriptives Statistics for 2006 Sample							
Beta	0.822	0.838	0.087	1.440	0.285	-0.190	2.692
StDv	0.961	0.330	0.020	14.540	1.783	4.612	27.472
VAIC	2.638	2.080	-11.370	47.110	5.923	4.680	30.552
LNA	13.230	12.890	9.830	18.300	1.816	0.699	0.057
Lev	26.814	27.850	0.170	69.280	14.877	0.308	0.213
DOL	6.704	0.236	-680.000	692.360	109.583	1.036	27.798
ROE	8.476	9.650	-91.500	69.340	19.222	-1.541	7.414
TQ	2.157	1.340	0.580	23.710	3.008	5.227	30.965
AGE	11.623	9.000	0.000	36.000	9.403	1.204	0.801
Panel B: Descriptive Statistics for 2011 Sample							
Beta	1.131	1.141	0.390	1.749	0.290	-0.147	2.450
St.Dv	0.975	0.410	0.020	14.830	1.860	4.633	26.831
VAIC	2.389	2.015	-8.720	27.680	3.730	2.895	18.201
LNA	13.302	12.938	9.561	18.850	1.870	0.718	0.247
Lev	32.485	31.965	0.030	92.140	17.540	0.362	0.489
DOL	17.929	1.608	-1,316.000	1,801.000	295.120	1.354	16.060
ROE	4.120	2.770	-114.200	34.090	131.380	-7.297	54.971
TQ	1.363	1.040	0.410	8.000	1.200	3.825	15.771
AGE	16.623	14.000	5.000	41.000	9.400	1.204	0.801
Panel C: Descriptive Statistics for 2016 Sample							
Beta	0.607	0.620	0.120	1.229	0.204	-0.110	2.700
St.Dv	0.555	0.220	0.010	7.780	1.011	4.186	21.897
VAIC	1.622	1.615	-12.690	16.140	2.728	-0.050	11.565
LNA	13.306	13.085	9.560	18.924	1.937	0.687	0.101
Lev	30.771	31.570	0.000	132.220	20.920	1.311	3.582
DOL	-71.490	1.092	-10,60.000	1,101.300	962.187	-10.590	113.430
ROE	5.708	3.690	-109.100	137.880	43.432	-3.948	30.788
TQ	1.144	0.965	0.350	5.380	0.650	3.617	17.494
AGE	21.623	19.000	10.000	46.000	9.403	1.204	0.801

Table 3: Beta multivariate regression analysis

Beta = dependent variable	Coefficient	p-value
Intercept	0.5191	0.0002 ***
VAIC	0.0049	0.0415 **
ROE	−0.0005	0.0156 **
Lev	0.0165	0.0823 *
LNA	−0.0150	0.0974 *
TQ	0.0232	0.0018 ***
Age	0.0026	0.3183
DOL	0.6655	0.0013 **
N	390	
R-squared	0.482	
Adj. R-squared	0.471	
P-value (F)	1.68e-06	
Akaike	811.8974	

Table 3 reports regression analysis output for Equation (1), where Beta is regressed on the variable of interest, VAIC and a set of controls. *,**,*** indicate statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. Variable definitions can be found in Table 1.

Thus, consistent with our expectation, Equation (2) supports the hypothesis that firms with greater values of intellectual capital experience more volatility in stock returns (i.e. more idiosyncratic/specific risk).

Table 4: Std. Dev. Multivariate Regression Analysis

Std. Dev.= dependent variable	Coefficient	p-value
Intercept	−0.5025	0.0071 ***
VAIC	0.0158	0.0065 ***
ROE	0.0006	0.2904
Lev	0.0031	0.0016 **
LNA	−0.0548	0.0606 *
TQ	0.3792	<0.0001 ***
Age	0.0101	0.0973 **
DOL	−0.0000	0.7391
N	390	
R-squared	0.391	
Adj. R-squared	0.385	
P-value(F)	1.78e-06	
Akaike	923.32	

Table 4 reports regression analysis output for Equation (2), where Std. Dev. is regressed on the variable of interest, VAIC and a set of controls. *,**,*** indicate statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. Variable definitions can be found in Table 1.

Also worth noting, the coefficient estimate on VAIC in Equation (2) is larger (and statistically significant at a higher level) than in Equation (1). This implies that the VAIC affects the standard deviation of stock returns more than the beta coefficient.

Controlling for Leverage Ratio and DOL, we verify prior research that theorizes and finds these variables to be determinants of beta (Hamada, 1972; Rubinstein, 1973; Mandelker and Ghon Rhee, 1984), showing that DOL and Leverage Ratio magnify the intrinsic business risk of common stock. Consistent with Banz (1981) and Binder (1992), we find firm size inversely relates to volatility for both specific and systematic risk.

Conclusion

In this study, we find a significantly positive relation between the extent of a firm's intellectual capital and its stock market volatility/risk (both systematic and idiosyncratic risks). Taken together these results are consistent with the stock market having difficulty measuring the intangible intellectual capital and/or knowledge-based economies that rely on intellectual capital being more dynamic and inherently volatile.

In both models, we verify that VAIC and Tobin's q are significantly positively related to the volatility of firm. Additionally, models estimate that both VAIC and Tobin's Q have a greater impact (larger estimated regression coefficients with more or similar levels of statistical significance) on the standard deviation of returns than market beta. This novel finding adds to the literature by showing intangible assets, including intellectual capital, are important determinants of firm's specific risk.

Prior literature has examined how intellectual capital relates to firm value reflected in the stock market. We contribute to this literature around intellectual capital and stock market behavior by providing evidence concerning the relation between intellectual capital and a key stock market characteristic, volatility. Understanding this relation should have many practical benefits for investors tasked with understanding the risks inherent to particular investments and whether those risks can be diversified away or are sufficiently compensated for with higher returns. Additionally, understanding this relation is of use to regulators tasked with maintaining stability within markets while operating with scarce resources.

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Author's Contributions

Brett W. Cantrell: Contributed to the writing/editing of the manuscript, organization of the study, discussion and conclusion, and the structure of the manuscript.

Daniela Coluccia, Stefano Fontana and Silvia Solimene: Contributed to the Theoretical Background of the manuscript, Development of the Hypothesis and Statistical Model, and Discussion/Conclusion.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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