Revealing a Non-Linear Relationship Between Knowledge Assets and Firm's Value

Kyriakos Christofi, Pieris Chourides and George Papageorgiou
SYSTEMA Research Centre, School of Business Administration, European University Cyprus, Nicosia, Cyprus

Ky.christofi@external.euc.ac.cy
P.chourides@euc.ac.cy
G.Papageorgiou@euc.ac.cy

Abstract: This paper investigates the effects of knowledge assets on firm's value. Developing knowledge assets has been gaining momentum in recent years under the lens and scope of knowledge management. However, there is an ongoing debate regarding the optimum level and combination of knowledge assets that would lead to firm's value maximization. The aim of this paper is to provide a resolution to this debate by investigating how knowledge assets affect firm's value and competitiveness in a real market context. By means of accounting indicators data, an examination is carried out on the identifiable knowledge assets derived from company annual reports. Consequently, the impact on firm's value over time is explored via multiple regression analysis using panel data. As a result, the optimal structure/balance between internal and external knowledge assets that lead to maximum market value is explored. The main findings show that knowledge assets generate greater firm value when they are coupled with complimentary assets. Additionally, externally acquired knowledge is equally important as knowledge which has been developed from internal research and development efforts. As a result, it is shown that an optimal balance between internal and external knowledge assets leads to greater firm value. Note that while similar studies tend to explore the impact of knowledge assets on various aspects, such as international and innovation performance, little has been done to investigate the impact of knowledge on the overall value of the firm. The presented study is not limited to product development, but it takes into consideration the capitalization of those products in the real market context. Thereby, managerial implications are explored, and suggestions are given on specific structures of knowledge assets that maximize organizational value.

Keywords: Knowledge management, Strategic management, Knowledge assets, Knowledge acquisition, Firm value

1. Introduction

In today's turbulent and highly competitive business environment knowledge assets are becoming a crucial component for developing unique strengths for almost any organization. As suggested by (Munjal, et al., 2022; Denicolai, Ramusino and Sotti 2015) such intangible assets can provide a business the capacity for creating a sustainable competitive advantage. Intangible assets are defined by the International Accounting Standards (IAS, p.38) as "*scientific or technical knowledge, design and implementation of new processes or systems, licences, intellectual property, market knowledge and trademarks*". This definition captures the whole spectrum of assets related to a firm's knowledge. Note that several scholars in the field (Zhang, et al., 2021; Doytch, 2021; Martinez, Zouaghi and Garcia 2017; Denicolai, Zucchella and Strange, 2014) distinguish between the knowledge assets and the totality of intangibles, referring to the subcategories of copyrights, licences, patents, development cost, self-generated software and design models. Taking such an approach, scholars are able to capture the value of assets that directly contribute to product advancement and breakthrough innovations (Denicolai, Ramirez and Tidd 2014).

In recent years, there is a growing interest on the investigation of firms' knowledge assets with respect to many areas of competitiveness. For instance, Denicolai, Ramusino, and Sotti (2015), highlight that organizations, which invest to the development and the acquisition of knowledge assets exhibit greater performance and potential for growth. Denicolai, Zucchella and Strange (2014) as well as Munjal, et al., (2022), argue that knowledge assets act as a catalyst to a firm's international expansion. Similarly, Zhang, et al., (2021), found that knowledge assets support the speeding up of a corporation's internationalization. Additionally, Uddin, Hasan and Abadi (2022), report that corporations which invest on intangible assets show resilience in periods of exogenous shocks.

Further, an important suggestion coming from the aforementioned studies is that knowledge assets should also be combined with complimentary tangible and intangible assets in order to get to the maximum levels of performance. Denicolai, Zucchella and Strange (2014) for example, suggests that a combination ratio of around eighteen per cent of knowledge assets relative to other assets would lead to a maximum level of international

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performance. Similarly, Denicolai, Ramusino, and Sotti (2015), argue that knowledge assets should be combined with complementary assets to maximize firm's growth.

Despite the progress on somewhat revealing the role of knowledge assets, little has been done on how knowledge assets impact the company's overall market value, which is the ultimate indicator of success. Although studies have been focusing on investigating the contribution of knowledge intangibles to revenue growth, (Denicolai, Ramirez and Tidd 2014; Denicolai, Ramusino, and Sotti 2015), to profitability (Hsu & Cohen, 2019), to internationalization (Denicolai, Zucchella and Strange 2014; Munjal, et al., 2022), and to firm's performance (Zhang, et al., 2021), the direct influence of knowledge assets on the overall firms' value remains unknown.

To fill-in the gap in the literature this paper investigates the direct impact of knowledge intangibles on the company's overall value. We therefore seek to reveal the role and the optimal structure/combination of knowledge assets with other intangible assets that would bring companies to the maximum possible level of their market value. Our study thereby contributes to the field of knowledge management in relation to assets capitalization.

The next section provides the theoretical foundation for developing a series of hypotheses. This is followed by a description of the main research methods employed and the results section presenting the multiple regression analysis model with the main findings. Further on a discussion on managerial implications is conducted based on the findings, emphasizing the need for an optimal balance in the structure of knowledge assets. Finally, conclusions are drawn and recommendations are provided for maximizing firm value.

2. Literature Review

2.1 Knowledge Assets and Firms' Value

In today's high velocity business environment, where changes are occurring on a daily basis in multiple directions, intangible assets are considered by scholars as a catalyst to improve firm's productivity, efficiency and value creation, (Uddin, Hasan, and Abadi 2022; Hasan and Uddin, 2022; Eisfeldt and Papanikolaou, 2013; Denicolai, Ramirez and Tidd 2014). According to the knowledge-based view of the firm, sustainable competitive advantage relies on a firm's ability to generate, accumulate, apply and therefore effectively capitalize knowledge, (Grant, 1996). Thus, organizations should attempt to internally develop and externally acquire knowledge assets in an effort to constantly renew their knowledge portfolio. In this way firms could align with the highly competitive landscape (Zhang, et al. 2021; Uddin, Hasan, and Abadi 2022; Christofi, et al. 2021). The question that remains unanswered though is: what is the actual impact of intangible assets on the firm's value?

International accounting standards (IAS, p.38) define intangible assets as technical or scientific knowledge which is recognized only if it is identifiable from its goodwill and has the ability to generate future economic benefits. Therefore, intangible assets are associated with the firm's research and development, as well as with its innovation efforts reflecting the explicit nature of knowledge of a firm. (Yang and Driffield, 2022; Martinez, Zouaghi and Garcia 2017; Doytch, 2021; Hsu and Cohen, 2019; Denicolai, Zucchella and Strange 2014). In recent years, research on intangibles assets has been gaining momentum by revealing the role and effects of knowledge intangibles on various aspects of competitiveness. Specifically, scholars have examined the impact of knowledge intangibles on the internationalization process (Denicolai, Zucchella and Strange 2014; Zhang, et al., 2021; Kotler, et al. 2019), firms' growth (Denicolai, Ramirez and Tidd 2014), and innovation performance (Berchicci, 2013; Denicolai, Ramirez, and Tidd, 2016).

However, little has been done on investigating the direct effect of those intangibles on the firms' overall value. The value of a firm is estimated by the achieved performance on a specific timeframe and its potential for future development (Cho, 2020). Investing in knowledge assets would add to both performance and potential for future development. In today's knowledge economy, organizations through research and development (R&D) efforts and other strategic moves, attempt to create unique knowledge assets, that would allow them to enhance their competitiveness, and as a result to increase their overall value (Belderbos, Park, and Carree, 2021). Knowledge assets refer to technical know-how and other intangible assets. Several studies argue that knowledge assets serve as crucial organizational inputs since they can support the development and leverage of capabilities and competencies towards value generation (Cho, 2020; Asiaei, et al., 2021; Liu, Wu, and Han 2021).

The literature also includes several examples of more specific benefits of knowledge assets. Denicolai, Zucchella and Strange (2014), for instance found that knowledge assets can support corporations towards global expansion and influence international performance. Similarly, Zhang, et al., (2021) observe that knowledge

assets act as moderators between speed of internationalization and performance. Additionally, Denicolai, Ramirez and Tidd (2014) found that knowledge assets help firms to grow and create value over the long-term. Furthermore, Uddin, Hasan, and Abadi (2022), point out that organizations with high-level of knowledge assets show more resilience in economic-wide exogenous shocks, such as the COVID-19 pandemic.

An important element of the above studies is that knowledge assets would be more impactful when they are coupled with other complementary intangibles and tangible assets. For example, Denicolai, Zucchella and Strange, (2014) found that firms perform better in international markets, when they manage to balance their knowledge assets with complementary assets. In some cases, firms that rely exclusively on knowledge without properly structuring their assets portfolio, exhibit worse performance in foreign markets, as compared to those who balance their assets portfolio. Cuervo-Cazurra, Maloney, and Manrakhan, (2007) also stress out the role of complementary assets in internationalization. It was shown that the lack in complementary assets may limit the effectiveness in international markets. Organizational benefits that result from the proper balance of assets are not limited to internationalization. Cho (2020) argues that in order to create a sustainable competitive advantage and long-term value both intangible and tangible resources are important. As it is further explained tangible assets may result in efficiencies through economies of scale, whilst intangible and knowledge assets act as a catalyst for new product development, and the cultivation of an innovative culture.

Based on the above discussion we assume that there is an inverse quadratic relationship between knowledge assets and firm's value. To empirically investigate our assumption the following hypothesis is proposed:

H1 There is an inverse U-shape relationship between firm's knowledge assets and firm's value.

By carrying out hypothesis testing, we aim to explore if there is an optimal balance between knowledge and non-knowledge assets that lead organizations to maximize their overall value.

2.2 Internally Developed Vs Externally Acquired Knowledge Assets

The literature of knowledge management and intangible assets, shows that the choosing the source of knowledge and knowledge intangibles represents a major strategic decision. The main dilemma is whether a company should make or externally acquire its knowledge assets, (Keegan and Green, 2016). According to Ferraris, Santoro, and Dezi (2017), in an era of technological evolution the focus on internal capabilities and research and development activities are no more sufficient in order to create value on the long term. Therefore, organizations should explore opportunities in order to identify and externally obtain know-how and technological assets. In this way they would increase their innovation performance as well as improve their innovative outcomes (Ardito, et al., 2015; Bedford, et al., 2022).

Many scholars suggest a complementary combination of internal research and development investments and activities, with the externally acquired knowledge, where companies can improve their innovation performance and increase their overall competitiveness and value (Sun, Zhang, and Wang, 2022; Zhou and Li, 2012; Denicolai, Ramirez and Tidd (2014). For instance, Zhou and Li (2012) observed that companies that use deep internal knowledge in combination with external knowledge, show more capability in radical innovation development.

There are several benefits that result from the acquisition of external knowledge. First knowledge acquisition help organizations to avoid the familiarity trap by expanding their horizons beyond their existing technologies and capabilities (Almodóvar and Quyen, 2022). Second, external knowledge allows access to new practices of product development, new technologies, while it acts as a catalyst to localize innovation from aboard (Un, 2016; Aiello, et al., 2020). For instance, Lee, Park, and Bae (2017), observe that corporations which were engaged in technology licencing, present greater turnover from product development, as compared with corporations that have not integrated technology licencing into their innovation strategy. Third, knowledge acquisition allows organizations to faster fulfil knowledge gaps (Denicolai, Ramirez and Tidd 2016).

However, in order to capitalize on the benefits received from external knowledge sources, strong internal research and development capabilities are required (Tsai and Wang 2007; Berchicci, 2013; Santoro, Ferraris, and Winteler 2019). Acquisition of external knowledge may include hidden costs, and organizations should be very careful in examining the side effects of a potential takeover (Delgado-Verde, et al., 2021). Therefore, organizations should invest in internal research and development to enhance their internal capabilities and to improve their organizational absorptive capacity. Stronger internal R&D capabilities lead to effective recognition of missing knowledge and result to greater absorption and integration of the acquired knowledge (Berchicci, 2013; Santoro, Ferraris, and Winteler 2019). Denicolai, Zucchella and Strange (2014), suggest that strong internal R&D capabilities allow companies to have a holistic view on how the external knowledge suits the overall

business model. This contributes to the value creation process. Additionally, Tsai and Wang (2007) study the effect of external technology licencing on financial performance. Their findings argue that external technology positively influence financial performance only in the presence of internal R&D efforts.

As a result, we conclude that externally acquired knowledge should be part of a firm's knowledge assets portfolio. Additionally, the externally acquired knowledge assets should be complementary to internal knowledge. This realization points out to the need for an investigation for the optimal balance, between internal and externally acquired knowledge assets. Therefore, expanding on the previous hypothesis for an inverse quadratic relation between external knowledge intangibles and firms value we built the following hypothesis.

H2 There is an inverse U-shape relationship between firm's external knowledge assets intensity and firm's value.

3. Research Methodology and Data Sample

The empirical investigation carried out, relies on a panel data regression analysis model. Gathering of the data was performed with the application of a specific protocol relying on accounting values that serve as proxies for the variables under investigation. This technique was chosen for two main reasons. First, panel data allow us to test the hypotheses in a longitudinal manner, capturing in that way the influence of our explanatory variables across time (Wooldridge, 2010). Second, accounting indicators create more robust measurements than survey methods, capturing the real value of knowledge, away from the threat of respondents' biases (Ketchen, Ireland and Baker 2012; Escribano, Fosfuri and Tribó 2009; Berchicci, 2013).

Data was obtained from the Revinitiv Eikon database (formerly Thompsons Reuters). Focus was placed on the European context, hence data was extracted from all the companies listed at European stock exchanges for the financial years of 2012-2021. European listed companies are drawn since they are required to use International Financial Reporting Standards (IFRSs). This ensures comparability across the dataset. Note that all European listed companies are using the same accounting principles.

After the initial extraction an application of a three criteria protocol is carried out, in order to reach out to the final dataset. First, we concentrated only on corporations which provide explanatory details about their "Intangible Assets" in their annual reports. Specifically, we included only firms that their annual reports state the book value of the following knowledge intangibles: copyrights, design models, self-generated software, know-how, acquired technology, licences, capitalized development cost, product development, and patents. Second focus was placed on the source of those intangibles. We included only corporations that clearly state whether the net book value of a specific knowledge intangible is a result of internally generated efforts or is externally acquired. Third, we have included only the companies that their fiscal year is until the end of December in order to avoid any time lags in our observations. Very similar criteria were applied in similar studies that investigate the effects of knowledge intangible assets (Denicolai, Zucchella and Strange 2014; Denicolai, Ramirez and Tidd 2016; Zhang, et al., 2021).

Table 1: Country and Industry Composition of the Final Sample

Country of exchange	Industry Classification Sector (ICS)					Total
	Healthcare	Industrial	Technology	Telecommunications	Other	
France	1	3	2	0	1	7
Germany	5	21	7	4	6	43
Switzerland	2	3	2	0	1	8
United Kingdom	11	26	16	2	3	58
Other	3	9	6	1	5	24
Total	22	62	33	7	16	140

After the application of the protocol our final dataset resulted in 140 companies that count for a total of 1184 observations. Table 1 indicates the distribution of our dataset with respect to the country of exchange coupled with the Industry Classification Sectors (ICS) classified by Financial Times Stock Exchange (FTSE) Russell's.

3.1 Measurements and Research Model

3.1.1 Dependent variable: Firm value

The depended variable refers to the firm value (VALUE) and we apply the Tobin's q (Chung and Pruitt, 1994) as a proxy to measure it. Tobin's q plays important role to financial interactions, and it is used to capture the market value of a firm over its assets (Lee and Makhija, 2009; Chung and Pruitt, 1994). Furthermore, Tobin's q is a forward-looking market base indicator that captures growth potential and investor expectation and is considered to be a superior proxy to company's value as compared to other accounting-based indicators. This is because it eliminates the threat of manipulations and distortions, which occur in the reporting process (Ahmad and Jusoh, 201; Ben-Horim and Callen , 1989; Hendratama & Huang, 2021; Noh, 2019). Following the common approach in the relevant literature, we apply the operationalization formula of Chung and Pruitt (1994), and Lee and Makhija (2009). Thus, we calculate Tobin's q as the sum of market value of common stock, the book value of preferred stock and debt respectively, divided by company's total assets.

3.1.2 Explanatory variables

As explanatory variables we include the firm's knowledge intensity (KNI) in terms of its assets and the firm's external sourcing intensity ratio (EXT). As mentioned earlier in this paper, our dataset consists of corporations that allow us to identify both their knowledge assets and their source of development. These are based on proxies that were previously used and therefore are acceptable by scientific community of knowledge management (Denicolai, Zucchella and Strange 2014, Denicolai, Ramusino and Sotti 2015, Denicolai, Ramirez and Tidd 2016; Zhang, et al., 2021). We calculate the firm's knowledge intensity as the ratio of the net book value of their knowledge intangibles over the net book value of the total non-current assets as presented on their yearly annual reports. Similarly, we calculate the external sourcing intensity ratio as the net book value of the external acquired knowledge assets over the net book value of the total knowledge assets. To test the existence of an inverse U-shape relationship of both explanatory variables we also include their squared term in our proposed model in order to capture possible interactions.

Further, several control variables are included into our proposed model. Specifically, we include the firm size (SIZE) and research and development intensity (RDI). We are interested to examine if large corporations capitalize their knowledge assets in different degrees of effectiveness as compared to small corporations. We also expect that corporations that invest heavily in the R&D function enjoy greater market value. Finally, we include the economic sector and country of exchange using dummy variables. Table 2 presents the exact operationalization of our valuables which result to the following multiple regression model (omitting the industry and country dummies):

$$\text{Firm Value}_{it} = \alpha + \beta\, KI_{it} + \gamma\, KI^2_{it} + \delta\, EXT_{it} + \varepsilon\, EXT^2_{it} + \eta\, Size_{it} + \theta$$

$$RDI_{it} + e_{it}$$

Table 2: Operationalization of Constructs

Dependent Variable		
Variable	**Operationalization**	**Source/ Adapted From**
Firm Value (Value)	$\dfrac{\text{Market value of } common\ stock + \text{Book value of } Preferred\ stock + \text{Book value of } Debt}{Book\ value\ of\ total\ assets}$	Lee and Makhija, (2009)
Explanatory Variables		
Knowledge Intensity (KNI)	$\dfrac{Net\ Book\ Value\ of\ Knowledge\ Assets}{Net\ Book\ Value\ of\ Non\ current\ Assets}$	(Denicolai, Zucchella and Strange 2014; Denicolai, Ramirez and Tidd 2014; Zhang, et al., 2021)
External Knowledge Sourcing (EXT)	$\dfrac{Net\ Book\ Value\ of\ Externally\ \text{Acquired}\ Knowledge\ Assets}{Net\ Book\ Value\ of\ Knowledge\ Assets}$	Denicolai, Zucchella and Strange 2014; Denicolai, Ramirez and Tidd 2016.
Control Variables		

Size	ln (Turnover)	Denicolai, Ramirez and Tidd, 2016
Research and Development Intensity (RDI)	$\frac{\text{Research and Development Expenses}}{Revenue}$	Denicolai, Ramirez and Tidd 2014; 2016); (Cheng and Shiu, 2020)
Industry dummies	TECH = 1 if company is classified as part of technology sector = 0 otherwise IND = 1 if company is classified as part of industrials and materials sector; 0 = otherwise. TELEC = 1 if company is classified as part of telecommunications sector; 0= otherwise HEALTH = 1if company is classified as part of healthcare sector; 0= otherwise	
County dummies	UK = 1 if company is listed in the UK; = 0 otherwise SW = 1 if company is listed in Switzerland; = 0 otherwise FR = 1 if company is listed in France; = 0 otherwise GER = 1 if company is listed in Germany; = 0 otherwise	

3.2 Descriptive Statistics

Table 3 indicates the range, as well as the Pearson correlation coefficients of the main continuous variables in our study. As shown on Table 3, our dataset includes both companies that invest heavily on research and development and rely on a notable amount of knowledge assets. It also includes companies that invest only a minimal amount of their profits on research and development. Similarly, out dataset includes both companies that rely exclusively on internally generated knowledge assets and companies that rely exclusively on externally acquired intangible assets, since the range of external sourcing ratio (EXT) range from 0-1.

Further, correlation tests were carried out between the key explanatory variables. The tests exhibit low correlation coefficients, thus reducing the presence of multicollinearity in the proposed model. This was verified by a variance inflation factors analysis (VIF). The calculated values range from 0.686 to 1.459, indicating that no multicollinearity is detected among the independent variables since the accepted value is up to 10. (Hair, et al., 1995; Battisti, et al., 2021)

Table 3: Means, Standard Deviations and Correlation Coefficients

	Obs.	Min	Max	Mean	Std. Deviation	Value	RDI	SIZE	KNI	EXT
VALUE	1184	0.1060	8.5243	1.6565	1.211	1				
RDI	1184	0.0001	0.9694	0.0714	0.100	.245**	1			
SIZE	1184	12.7924	25.8751	19.9741	2.284	-.212**	-.375**	1		
KNI	1184	0.0017	0.8871	0.1877	0.169	.163**	.429**	-.471**	1	
EXT	1184	0.0000	1.0000	0.4196	0.299	-.061*	-.081**	.255**	-.249**	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

4. Empirical Results

We first estimate our model by including only the control variables: R&D intensity, size, as well as industry and country dummies. The explanatory power of this initial model is relatively low (R2 0.2220), but is better than similar models in the field (Denicolai, Zucchella and Strange, 2014). As it is indicated in our regression results (see table 4, model 1) the country dummies of the United Kingdom and Switzerland present a positive and statistical significance influence on firm's value. This result is not surprising since the London stock exchange is one of the most active stock exchanges and an attractive destination for cross-listing where companies show higher overall valuation (Ghadhab and Hellara, 2016). Furthermore, Switzerland is considered to be the most innovative economy worldwide, as it ranked first for twelve consecutive years at the global innovation index

(GII). This is reported by the world intellectual property organization (WIPO, 2022) in collaboration with academic and industrial partners.

Looking at the various economic sectors of Table 3, we see that technology, healthcare, and industrial sector present positive and statistical significance influence on firm's value. This means that corporations operating in these economic sectors create greater value than the rest in our sample. This is expected since they are considered the most rapidly valuable sectors that even in time periods of negative financial shocks their stocks exhibits a positive return (Mazur, et al., 2021). Research and development intensity (RDI) also shows positive, statistically significant results ($p<0.01$). In our analysis there seems to be no impact of the size of the firm on the firm's value. Further our results are in alignment with the mainstream literature, which supports the view that R&D investments contribute to the firm's overall value (Peters, Roberts, and Vuong 2022; Rababah, Molavi, and Doust, 2022; Rahman and Howlader, 2022).

As a second step the model is extended (see model 2 in table 4) by adding the variable of knowledge intensity in order to examine the role of knowledge assets on affecting firm's value. As a result, the explanatory power of our model slightly increases in relation with the initial model ($R2 = 0.2347$). The results indicate that knowledge intensity (KNI) has a positive impact on firms' value, which is statistically significance ($p<0.01$), while its squared term (KNI2) shows a negative impact which is also statistically significant ($p<0.01$). Therefore, we may conclude that an inverse U-Shape relationship exists between the firm's knowledge assets and its value. This finding supports hypothesis 1. In other words, knowledge assets can help organizations to increase their real market value across time, but only up to a point. Note that our results are consistent with the mainstream literature, which argues that knowledge assets should be combined with complimentary assets in order to lead companies to a maximum level of performance (Cho, 2020; Belderbos, Park, and Carree, 2021; Denicolai, Zucchella and Strange 2014).

Table 4: Regression Results

Variable	Model 1	Model 2	Model 3
UK	0.3564***	0.4388***	0.4234***
	(0.1066)	(0.1063)	(0.1077)
GER	-0.1940**	-0.1287	-0.1502
	(0.0935)	(0.0937)	(0.0960)
FR	-0.0882	-0.0615	-0.0241
	(0.1988)	(0.1987)	(0.1937)
SW	1.0053***	1.1159***	1.0789***
	(0.1780)	(0.1763)	(0.1756)
TECH	0.6552***	0.6117***	0.6122***
	(0.1194)	(0.1188)	(0.1217)
IND	0.2281***	0.2735***	0.2751***
	(0.0849)	(0.0836)	(0.0877)
TELEC	-0.0504	-0.1744	-0.1375
	(0.0935)	(0.1014)	(0.1046)
HEALTH	1.0184***	1.0002***	0.9858***
	(0.1392)	(0.1364)	(0.1399)
RDI	1.5472***	1.4356**	1.4513**
	(0.5891)	(0.6159)	(0.6201)
SIZE	0.0025	0.0248	0.0229
	(0.0153)	(0.0152)	(0.0157)
KNI		2.4628***	2.4052***
		(0.5711)	(0.5561)

Variable	Model 1	Model 2	Model 3
KNI²		-2.8967***	-2.7758***
		(0.8699)	(0.8571)
EXT			0.7254*
			(0.4211)
EXT²			-0.8478**
			(0.4118)
cons	0.9625***	0.1835	0.1577
	(0.3480)	(0.3491)	(0.3537)
Obs	1184	1184	1184
R²	0.2220	0.2347	0.2380

Notes:

1. Robust standard errors in parenthesis

2. * Denotes that the regression coefficient is significant at the 10%; ** at the 5%; *** at the 1%

Organizations therefore should find the optimal ratio of knowledge assets over their total non-current assets that will drive them to the maximum possible level of value. The relative size of the estimated coefficients suggests a turning point at about KNI = 0.425. In practice, this means that corporations investing on the development of knowledge assets create value across time. However, those corporations that have more than 42.5% knowledge assets in relation to other assets they could exhibit a fall in their market capitalization capability. As a result, a need emerges for firms to couple their knowledge assets with other long-term investments on assets.

Finally, we extent our model by including two more terms related with the source of knowledge (EXT and EXT2), in order to examine the effects of externally acquired knowledge on firm's value (see model 3 in table 4). The result of adding those terms leads once again to the improvement of the explanatory power of our model (R2 = 0.2380). The estimated coefficients for knowledge intensity as well as for the control variables show enough robustness since they retain their level of significance. In this case the knowledge intensity ratio, that gives value maximization is slightly increased to 0.4332 (43.3%) showing a 1% difference as compared with the previous model.

Our results show positive effect (statistical significance, $p<0.1$) of external knowledge intensity (EXT) on firms' value, while its squared term (EXT2) show a negative effect ($p<0.05$). In other words, externally acquired knowledge help organizations to increase their overall value but only up to a point since such internal knowledge is required to lead organization to a maximum level of value. Based on our results an inverse U- shape relationship between external knowledge assets intensity and firm's value is clearly present, thus hypothesis 2 is also supported.

Our findings are supporting the views for the complementary role of external knowledge (Berchicci, 2013; Santoro, Ferraris, and Winteler 2019; Denicolai, Zucchella and Strange 2014; Tsai and Wang 2007; Almodóvar and Quyen, 2022 Sun, Zhang, and Wang 2022; Zhou and Li, (2012) Bedford, Bisbe, and Sweeney 2022). We may also argue that external knowledge acquisition can be better capitalized only if there are strong internal R&D capabilities and abortive capacity. This view suggests that organizations should investigate for an optimal balance between internal and external knowledge in order to maximize value. The relative size of the estimated coefficients suggests a turning point at about 43%. In practice this can be interpreted that organizations should build strong internal R&D capabilities. These capabilities can then act as the foundation to host external knowledge as a complement to maximize the capitalization of their knowledge assets. The suggested percentage is that externally acquired assets should account for approximately 43% over a firm's total knowledge assets.

5. Discussion - Managerial Implications – Conclusion

In this paper we investigate the role as well as the structure of knowledge assets in relation to firm's value over time. Developing a multiple regression model using several accounting indicators we show that companies should invest on a complementary balance of knowledge assets in relation to other assets. Note that overreliance on knowledge assets could erode the market value of the firm. In other words, knowledge assets are more effectively capitalized when they are coupled with other tangible assets such as facilities, as well as intangible long-term assets, such as customer and supplier relationships. We argue that the optimal percentage of knowledge assets over a firm's total non-current assets is approximately 43.3%. This would on average lead to maximum firm value.

Further, we found that acquisition of knowledge assets from external sources can also increase firm's value. However, this should be coupled with internal research and development capabilities and other internally existing knowledge. We observe that organizations with an overreliance on externally acquired knowledge are valued less than organizations, using external knowledge as a complement in their internal knowledge assets portfolio. Specifically, we argue that the optimal percentage of external knowledge assets over the corporation's total knowledge assets is approximately 42.8%.

This paper contributes to the literature of knowledge management and the debates over role of knowledge assets. First it contributes to the knowledge management field with respect to revealing the role of knowledge assets with respect to different aspects of performance. Some researchers argue that companies should focus on the development of as many knowledge assets as possible, in order to increase their performance and competitiveness (Kuivalainen, et al., 2004; Asiaei, et al., 2021). Contrary to this argument, our results suggest that the relationship between knowledge assets and firm's value is non-linear. In fact, complementary other assets are also required in order to maximize the benefits received from knowledge intangibles. Our findings are in alignment with the complimentary views on the role of knowledge assets (Cuervo-Cazurra, Maloney, and Manrakhan 2007; Denicolai, Zucchella and Strange 2014; Zhang, et al., 2021; Cho, 2020). Therefore we argue that firm's value can be maximized by combining knowledge assets with both tangible and intangible resources.

Finally, this paper contributes to the current state of knowledge by examining the market value that is gained through acquiring knowledge assets. Most studies are limited to specific dimensions of performance such as internationalization (Cuervo-Cazurra, Maloney, and Manrakhan 2007; Denicolai, Zucchella and Strange, 2014), and innovation performance (Aiello, et al., 2020; Un, 2016; Almodóvar & Quyen, 2022). The majority of studies examine the effects of knowledge assets with ratios that are mainly developed based on sales and the commercialization of new products. Our study investigates the impact of knowledge assets on the overall firm's value, capturing in this way the ability of firms to capitalize on knowledge in a real market context.

Our investigation makes also methodological contributions. The application of accounting indicators and the proposed applied protocol allowed us to focus to the knowledge intangibles by investigating the optimal level and source that can lead to maximum level of market value. Such an approach, provides a more solid set of proxies than merely investments on research and development. In this way we capture in our model the real market value of corporations and we examine how firms capitalize value based on their assets.

Similar to all empirical and conceptual investigations, this study has its own limitations. First it relies on accounting indicators that mainly capture only the explicit knowledge of the firm. Second it focuses on corporations that are listed in stock exchange markets of advanced economies. In advanced economies or high-income countries, corporations mainly compete by developing knowledge assets and new product innovations (Keegan and Green, 2016). Therefore the findings of this study may not be entirely generalized for the case of emerging or developing economies. It would be therefore interesting to carry out further research and derive the optimum ratio of internal/external knowledge assets for firms in emerging/developing economies. Such findings could then be compared to the optimum ratio of firms in advanced economies.

Future research could also be carried out to examine the role of tacit knowledge on the capitalization ability of knowledge assets, as well as to examine different knowledge assets structures under different levels of tacit knowledge. On more point is that the current study merely focuses on internal and external knowledge assets. It would be interesting to further examine the various types of partnerships among corporations and to investigate if there is an optimal balance among open innovation strategies that lead to better assets capitalization. Moreover, there is an emerging trend in the literature that examines the effectiveness of firms' intellectual capital (Chen, Cheng and Hwang, 2005; Nadeem, Farooq and Ahmed, 2019). The effectiveness or value-added intellectual capital VAIC is also measured based on accounting indicators, as initiated and calculated

by (Nazari and Herremans, 2007). It would therefore be quite interesting for a future study to investigate an optimal balance, if any between external and internally development knowledge assets that lead to the maximization of intellectual capital effectives. Definitely, the field of knowledge management is rapidly changing with tremendous possibilities for future development. Revealing some of the subtle interrelationships between knowledge assets and firm's value could act as guide for developing effective strategies in highly complex business environment.

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