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The moderating role of human capital

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Abstract

Purpose – The purpose of this paper is to investigate the relationship between intellectual capital (IC), categorized in terms of four sub-constructs – namely, human capital (HC), relational capital (RC), innovation capital (InnC) and process capital (PrC) – and business performance in the agribusiness industry.

Design/methodology/approach – Based on a sample of international agribusiness companies observed over a five-year period, this paper uses correlation and multiple regression analysis to test for the existence of a positive relationship between each IC component and conventional business performance metrics.

Findings – The empirical results support the hypotheses that RC and PrC have a positive impact on corporate performance. Counter to the expectations, InnC by itself is negatively associated with performance. Results also failed to confirm the hypothesis that HC directly and positively affects performance. However HC positively moderates the relation between InnC and performance, which suggests that firms that heavily invest in HC are better placed to gain returns from their research and development (R&D) investments.

Originality/value – This study expands the existing research on the link between IC and performance by adding fresh evidence from a highly knowledge-intensive sector which has been under-researched thus far. It may also contribute to the specific literature on R&D and performance as it uncovers that the value-generating effect associated with R&D investments is contingent on the levels of HC.

Keywords Innovation, Firm performance, Human capital, Intellectual capital, Agribusiness

Paper type Research paper

1. Introduction

The rise of the knowledge economy has led to a growing reliance on intellectual or knowledge-based assets as the new source of competitiveness for firms, countries and regions (Ordóñez de Pablos and Edvinsson, 2015; Schiuma and Lerro, 2015).

According to the resource-based view of the firm (Barney, 1991), only resources that are valuable, rare, non-substitutable and hard-to-imitate – which are referred to as “strategic assets” (Hall, 1992) – would provide sustainable competitive advantage and superior financial performance. Both tangible and intangible resources may qualify as strategic assets. However, in the current “knowledge era” the only resource that seems

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to strictly meet the above criteria is intangible (knowledge-based) capital, due to circumstance that physical tangible assets such as property, plant and equipment and physical technologies are increasingly easy-to-imitate, substitutable and can be purchased and sold on the open market (Riahi-Belkaoui, 2003; Roos and Roos, 1997).

Further, not all intangibles become intellectual capital (IC) assets but only those which possess the necessary requisites of strategic resources (Riahi-Belkaoui, 2003). Ante Pulic (2008, p. 5), an influential IC theorist, clarifies that IC consists of knowledge that serves the purpose of creating "value identifiable on the market" or "benefits the customer pays for". This implies that are excluded all intangibles that have no impact on the value-generating potential of the firm. In a similar vein, Riahi-Belkaoui (2003, p. 215) affirms that the strategic significance of IC rests on a "potential link between intellectual capital on one hand and firm performance on the other hand".

Many scholars have endorsed the view that IC is a primary source of sustainable competitive advantage and superior performance (Bontis, 1996, 1998, 2001; Edvinsson and Malone, 1997; Roos *et al.*, 1998; Stewart, 1997; Sveiby, 1997). Scholars have also consistently observed that the traditional financial and accounting instruments fail to capture all the relevant dimensions of IC and report them to organizational managers and stakeholders (Nazari and Herremans, 2007). Thus the need has become clear for a systematic approach to visualize and measure IC (Roos and Roos, 1997).

Over the past decades IC researchers have been striving to provide reliable measures of IC and test their relationship with business performance. As a result, a surge of writings and empirical studies has accumulated (e.g. Bassi and Van Buren, 1999; Bontis *et al.*, 2000; Chan, 2009; Chen *et al.*, 2005; Firer and Stainbank, 2003; Maditinos *et al.*, 2011; Pulic, 2000; Riahi-Belkaoui, 2003). By now a good deal of evidence exists supporting the positive causal linkage between IC dimensions and firm performance (for the most recent review of the empirical literature see Inkinen, 2015).

The extant IC research has covered a range of industry contexts and particularly knowledge-intensive industries such as banking (e.g. Cabrita and Bontis, 2008; El-Bannany, 2008; Mention and Bontis, 2013; Mondal and Ghosh, 2012), financial (e.g. Appuhami, 2007; Joshi *et al.*, 2013), insurance (e.g. Alipour, 2012), information technology (IT) (e.g. Wang and Chang, 2005), pharmaceutical (e.g. Mehralian *et al.*, 2012; Sharabati *et al.*, 2010) and hotel industry (e.g. Engström *et al.*, 2003; Zeglat and Zigan, 2014). This paper extends these prior investigations by using the agribusiness industry as a research setting.

Agribusiness industry can be defined as a set of interconnected vertical markets with firms operating in the production, processing and wholesale marketing of agricultural products. For the purposes of this paper, we narrow the scope of the agricultural context by considering only seed and agrochemical companies. It is to be outlined that top international agrochemical companies are also seed industry giants. Indeed, the global seed industry is presently dominated by multinational chemical enterprises which over recent decades have been increasingly interested in investment in agro biotechnology-related sectors, thus evolving into "life sciences" giants for the development and production of such products as agricultural chemicals, seeds, foods and food ingredients (Fernandez-Cornejo, 2004).

A study of IC in this industry context appears to be both appealing and appropriate, first because global agribusiness is heavily reliant on IC notably in terms of research and development (R&D)-related activities and intellectual property rights. Second the process of marketing seed varieties and chemical companion is also knowledge intensive and thus provides a fruitful setting for IC assessment. Nevertheless, this industry has thus far gone underexplored in IC research, which to the best of our knowledge has produced only a handful of specific studies (Lee and Shaiban, 2014; Sporleder and Moss, 2004). In order to fill this void, this paper empirically investigates the impact of IC on business performance in a sample of global agribusiness companies.

The remainder of the present paper is organized as follows: the next section develops the conceptual framework for this study based on a review of the relevant literature on IC and firm performance; the following section describes the research methodology and data collection; the penultimate section presents and discusses our empirical findings; the final sections conclude the paper also outlining research limitations and future directions.

2. Literature review

The concept of IC has evolved from different academic disciplines and has increasingly become an interdisciplinary field (Marr, 2007), which is also the reason why there is no single definition or categorization of IC. Stewart (as cited in Bontis, 1998, p. 65), defines IC as "the intellectual material – knowledge, information, intellectual property, experience – that can be put to use to create wealth". Similarly, Brooking (1996, p. 12) defines IC as "the combined intangible assets of market, intellectual property, human-centered and infrastructure which enable the company to function". Roos *et al.* (1998, p. 25) refer the term to "all the processes and the assets which are not normally shown on the balance sheet, as well as all the intangible assets which modern accounting methods consider […] Brands and trademarks as well as the management of relations with external parties […] are all dimensions of value creation". However, Choo and Bontis (2002) argue that IC does not include intellectual property assets and that, even though the latter (e.g. a patent) can be considered an output of the former, they are "mutually exclusive" categories.

Even though IC definitions may differ to some extent, all of them stress the growing importance of knowledge-based capital and its potential link with value creation. Furthermore, scholars have consistently described IC as a multidimensional construct, emphasizing the notion that knowledge exists at different levels in organizations (e.g. human and non-human storehouses of knowledge). Several authors have offered their own classifications or taxonomies of IC in an attempt to provide a working definition for research purposes (see Tan *et al.*, 2007). However, these schemes seem to converge to a large extent.

The conceptual framework of this paper is based on the IC taxonomies put forward by Edvinsson and Malone (1997), Roos and Roos (1997), Stewart (1997) and Sveiby (1997). Though slightly different, these taxonomies share the common ground that IC is comprised of human capital (HC), structural capital (SC) and customer (or relation) capital (RC). SC is in turn broken down into innovation capital (InnC) and process capital (PrC) (Choo and Bontis, 2002; Edvinsson and Malone, 1997; Edvinsson, 2002; Joia, 2000).

Our study subscribes to this classification and sub-divides the high-order construct of IC into four components, namely, HC, RC, InnC and PrC. Each IC component is then assumed to positively affect business performance, as many research studies have shown.

2.1 HC

HC or, in Brooking's (1996) words, human-centred assets are the collective expertise, creative and problem solving capability, leadership, entrepreneurial and managerial skills embodied by the employees of the organization.

In the knowledge-based era of business activity, HC is a key element of value creation. Bontis (1998) argues that HC is important because it serves as a source of innovation and strategic renewal. On the other hand, a basic problem with human assets is that they cannot be owned. As Becker (1964) points out, expenditures on employees such as training or education are investments in capital, however they "produce human, not physical or financial, capital because you cannot separate a person from his or her knowledge, skills, health, or values the way it is possible to move financial and physical assets while the owner stays put". This implies that the departure of key employees may result in a loss of corporate intellectual ability and knowledge leakages, thus posing risks for the competitiveness of the firm (Olander *et al.*, 2015).

In the empirical literature HC is usually assumed to affect performance positively, and sufficient evidence has amassed to support this claim. To name a few, Chen *et al.* (2005) showed that HC had a positive effect on firms' market value and profitability within Taiwan listed companies. Kamath (2008) found that HC had a major impact on profitability and productivity for top firms in the Indian drug and pharmaceutical industry. Ting and Lean (2009) have shown that HC has a positive relationship with the profitability (return-on-assets (ROA)) of financial institutions in Malaysia. However, the literature reports varied or contrasting results as well. Chu *et al.* (2011) found HC to be negatively associated with stock market performance (market-to-book value (M/BV), and positively associated with profitability (ROA), whereas they failed to show any significant relationship with the shareholders' return (return-on-equity (ROE)) and productivity (asset-to-turnover (ATO)). By contrast, Maditinos *et al.* (2011) based on a sample of listed Greek firms found HC to be positively associated with M/BV and ROE, but failed to demonstrate its association with ROA and firm growth. Eventually, Firer and Williams (2003) and Shiu (2006) found a significantly negative impact of HC on productivity (ATO) and stock market performance (M/BV).

Perhaps more insightfully, other research studies (e.g. Cabrita and Bontis, 2008; Cabrita *et al.*, 2007; Costa *et al.*, 2014; Kim *et al.*, 2012; Reed *et al.*, 2006; Subramaniam and Youndt, 2005; Veltri and Silvestri, 2011; Wang and Chang, 2005) revealed that HC may affect business performance (also) indirectly through its positive impact on the other types of IC. In other terms, there may exist a cause-and-effect relationship between HC and other elements of IC, such that HC may positively affect the other elements, and then these elements, in turn, affect performance. One major conclusion from this line of research is that HC, though definitely necessary, is not sufficient *per se* to deliver superior performance, but it needs be continuously coordinated with the other components of IC for an organization to leverage its overall intangible value.

2.2 SC

According to a highly cited definition (Roos *et al.*, 1998) SC is the knowledge that stays in the firm when employees go home for the night. It encompasses all knowledge stored in organizational infrastructures (e.g. databases, organizational procedures, patents and trademarks) and everything else of organizational capability that supports employees' productivity (Bontis, 2001).

SC is dependent on HC, since the latter is the primary factor for developing SC (Nazari and Herremans, 2007). On the other hand, SC acts as a supportive infrastructure for human resources: an individual can have a high level of intellect, but if the organization has poor systems and procedures by which to track his or her actions, the overall IC will not reach its fullest potential (Bontis, 1998). Unlike HC, SC components can be owned and traded by an organization (Edvinsson, 1997), at least to the extent that they can be legally protected and become intellectual property rights.

Edvinsson and Malone (1997) describe SC as comprised of customer capital and organizational capital, with the latter in turn subdivided in PrC and InnC. Similarly, Roos and Roos (1997) define structural capital – which they call organizational capital – as the sum of PrC and InnC, however they put RC on an equal footing with human and structural capital rather than a subcategory. Overall, these influential scholars agree on the notion that HC, InnC, PrC and RC are basic components of the IC construct.

2.3 PrC

PrC is the procedures, systems and techniques an organization adopts to achieve process quality and operational efficiency. The quality of internal processes represents an important business value indicator looked at by investors (Mavrinac and Siesfeld, 1998). Even more fundamentally, the improvement in PrC leads to customer satisfaction and enhancement of customer relationships (Wang and Chang, 2005). Therefore, PrC is somewhat of a leading IC element, which may influence corporate business performance not only through reducing the cost of operations but also via improved customer performance (Cheng *et al.*, 2010). After all, superior customer performance stems from process improvements that result in improvements in quality, cycle-time, quoted lead-time, delivery and new product introduction (Kaplan and Norton, 1992). Interestingly, research has found that efficient operating processes positively affect company performance through reducing the input costs of maintaining customer relationships such as selling, advertising and administrative expenses (Cheng *et al.*, 2010). Furthermore, Wang and Chang (2005) have shown that PrC (as measured by items such as value added per employee, plant assets turnover and administrative expense per employee) directly and positively affects economic and financial performance of Taiwan's IT firms.

2.4 InnC

InnC is an organization's capability to innovate and develop new products, services and solutions. Its main component is represented by R&D activities (Lev, 2001). Therefore, InnC is a critical IC component especially in knowledge-intensive organizations such as those under investigation. Agribusiness companies apply the biotechnology business model to agriculture in that they heavily invest in R&D and strive to recoup these investments through the use and enforcement of biological patents (e.g. genetically engineered seed patents).

Many empirical studies have shown that companies' R&D investments influence corporate business performance and market value, as well as future performance. For instance, Chen *et al.* (2005), using data drawn from Taiwanese listed companies, have found that current-year R&D expenditures have a significantly positive impact on profitability (ROA) and revenue growth. They have also shown that R&D expenditures are important for firms' future profitability and revenue growth. Prior research by Lev and Sougiannis (1996) has already established a causal connection between R&D expenditures and future performance. Their study has highlighted that the association between R&D outlays and future earnings is not only worth exploring from a statistical viewpoint but also economically meaningful.

Most recently a study by Chang and Hsieh (2011) has found a significantly positive association between R&D expenditures and operational, financial and stock market performance for Taiwan semiconductor companies.

Research has also shown that InnC (as measured by current R&D, last R&D expenses and number of R&D employees) has both a direct and an indirect impact on performance (Wang and Chang, 2005). As far as the latter is concerned, InnC is shown to indirectly influence business performance through its impact on PrC (operational efficiency), which in turn affects RC (via improved customer performance) and ultimately business performance.

2.5 RC

The essence of RC is the knowledge embedded in relationships external to the firm such as the knowledge embedded in customers, suppliers, stakeholders, the government or related industry associations (Bontis, 1998). RC is the most difficult of IC components to develop since it is the most external to the company's core (Bontis, 1998). As compared with other IC components, it more directly affects a company's bottom line, in that it acts as a bridge in converting IC into market value and thereupon corporate business performance (Chen *et al.*, 2004). An oft-cited study by Fornell (1992) found evidence that nurturing customer relationships via customer satisfaction lowers the elasticity of demand to price changes and improves company prestige. More recently, a study by Cheng *et al.* (2008) has shown that RC as measured by a composite index of quantitative items (such as selling expenses and sales to major customers) has a highly significant and positive effect on market value in a sample of listed healthcare companies. In a later study, the same authors (Cheng *et al.*, 2010) have used the input costs of maintaining customer relationship (i.e. selling and promotional expenses) to proxy for RC and found that the higher the cost of maintainable customer relationships the higher the positive impact on corporate performance.

Tseng and Goo (2005) have found that RC directly and positively influences firms' market value based on survey data from listed Taiwanese manufacturers. In line with this finding, Ferraro and Veltri (2011) have reported that RC is positively related to market value within Italian listed companies, suggesting that investors incorporate information on RC into their business valuation process.

In addition, several studies based on perceptual measures (i.e. survey data) of IC and performance have consistently found that RC positively affects performance (e.g. Bontis *et al.*, 2000; Cabrita and Bontis, 2008; Jardon and Martos, 2012; Mention and Bontis, 2013; Sharabati *et al.*, 2010).

3. Research methodology

3.1 Research objectives

The main objective of this study is to contribute to the existing research on IC and firm performance by providing new evidence from the agribusiness industry, thus far underexplored in this area of study. In order to fill this void, we investigated IC impact on a sample of 18 international agribusinesses from different home countries over a five-year period (2010-2014).

Similar to prior research (e.g. Chan, 2009; Chen *et al.*, 2005; Shiu, 2006), correlation and multiple regression analysis were used to assess whether our IC proxies could be strong predictors of business performance.

3.2 Research hypotheses

Based on mainstream literature on IC and performance, we expected IC components to be positively associated with firm performance as measured by four traditional accounting ratios, namely, the ATO, ROA, ROE and return-on-investment (ROI) ratios. In a more formal fashion, we propose the following research hypotheses:

H1. HC directly and positively affects performance (PERF).

H2. InnC directly and positively affects performance (PERF).

H3. PrC directly and positively affects performance (PERF).

H4. RC directly and positively affects performance (PERF).

3.3 Independent variables

Our key variables are four accounting-based proxies for HC, RC, InnC and PrC. The choice of these proxy variables is supported by prior IC research, as shown in Table I.

Expenditures for employees are a widely used proxy for HC in IC research. Pulic (2008, p. 7) explicitly states that "the human capital of a company is represented by its workforce and, in accounting terms, by the expenditures for employees". The rationale behind this is that expenditures for employees should be no longer regarded as costs but rather as asset-like investments, since employees and specifically knowledge workers are "the main value creators of contemporary economy" (Pulic, 2008, p. 5). In addition, the level of employee expenses is regarded as a rough proxy for a firm's ability to attract and retain talented people, which may be reflected in paying competitive salaries and bonuses. Based on these assumptions, some researchers have suggested the use of total labour expenditures (these including salaries, bonuses and other labour compensating packages) to capture HC (e.g. Ballester *et al.*, 2002; Lajili and Zéghal, 2005; Sydler *et al.*, 2014).

To proxy for RC, we have chosen to use the firms' reported sales, general and administrative (SG&A) expenses. This major income statement item includes (though not limited to) outlays related to the building of RC such as advertising and marketing

Table I.
Intellectual capital constructs and proxy variables

IC constructs	Proxy variables	Description	References
Human capital	Labour and related expenses	Include wages and salaries, social security, pension costs, profit sharing and other labour compensation packages	Van Buren (1999), Pulic (2000), Ballester *et al.* (2002), Swartz *et al.* (2006), Lajili and Zéghal (2005) and Sydler *et al.* (2014)
Relation capital	Selling, general and administrative expenses	Include the expenses not directly attributed in the production process, but related to sales, general and administrative functions	Danish Trade and Industry Development Council (1997), Cheng *et al.* (2008, 2010) and Gourio and Rudanko (2014)
Innovation capital	Research and development expenses	Include all the direct and indirect costs related to the creation and development of new processes, techniques, applications and products with marketing possibilities	Chen *et al.* (2004), Wang and Chang (2005), Bollen *et al.* (2005), Subramaniam and Youndt (2005) and Goebel (2015)
Process capital	Fixed-assets-turnover	Computed as the ratio of net annual sales to average fixed assets	Wang and Chang (2005), Chu *et al.* (2008), Cheng *et al.* (2010) and Yu *et al.* (2015)

expenses, product promotion expenses, sales people salaries, distribution expenses and depreciation of sales building and equipment. To be sure, not all of SG&A expenses generate RC – SG&A also include provisions for doubtful accounts, for example – but it appears reasonable to assume that most of the expenditures aimed at creating and enhancing RC are included in the companies' SG&A expenses. Gourio and Rudanko (2014), for example have used SG&A expenses to study the economic implications of investing substantial resources on creating and maintaining customer relationships. Other research articles using SG&A to proxy RC include Cheng *et al.* (2008, 2010) and Wang and Chang (2005). It is to be outlined that the vast majority of research testing the impact of RC on performance is survey based, whereas we choose to refer to an accounting proxy for RC in an attempt to provide and validate an alternative way to assess its impact on performance based on easily accessible data.

In order to measure the contribution of InnC to firm performance, we have sourced the R&D expenditures, an extensively used proxy for InnC (e.g. Chen *et al.*, 2004, 2005; Goebel, 2015; Wang and Chang, 2005). In some cases, the R&D expenses were charged to SG&A expenses, so we had to disentangle the former from the latter.

Eventually we have computed the fixed-assets-turnover ratio to serve as a proxy for PrC following prior research studies (e.g. Wang and Chang, 2005; Yu *et al.*, 2015). The fixed-assets-turnover ratio is regarded as a measure of intangibles-driven value creation, based on the assumption that companies with a higher fixed-assets-turnover are characterized as having the most efficient processes, a highly skilled workforce, efficient IT-systems and as a result are most likely to enjoy a higher productivity per unit of fixed resource.

All IC proxies, except for the fixed-assets-turnover, are standardized by total assets (scaling variable). Total assets can be regarded as the firm's available financial resources, hence these ratios reflect in a sense the willingness of firms to engage in IC-related investments conditional on the resources that are available to them (Lev *et al.*, 2009). In formulae, our independent variables are obtained as follows.

HC (Human Capital) = Labour & related Expenses/Total Assets

InnC (Innovation Capital) = R&D expenses/Total Assets

PrC (Process Capital) = Net Sales/Fixed Assets

RC (Relation Capital) = Selling, General and Administrative expenses/Total Assets

3.4 Dependent and control variables

As proxies for corporate performance, we have selected four common accounting measures which have been diffusely used in prior IC research.

ATO (Asset Turnover) = Total revenue/total assets (e.g. Firer and Stainbank, 2003; Zéghal and Maaloul, 2010)

ROA (Return-on-Assets) = Net income/total assets (e.g. Chen *et al.*, 2005; Firer and Williams, 2003; Shiu, 2006)

ROE (Return-on-Equity) = Net income/total shareholders' equity (e.g. Maditinos *et al.*, 2011; Tan *et al.*, 2007)

ROI (Return-on-Investment) = Operating income/total assets (e.g. Lev and Sougiannis, 1996; Zéghal and Maaloul, 2010)

Also consistent with prior studies, firm size and firm leverage were included in our regression models to control for their impact on the dependent variables.

Firm size (FSize), as measured by the natural logarithm of total sales (Riahi-Belkaoui, 2003), is used to control for the impact of size on wealth creation due to scale economies, monopoly power or bargaining power.

Leverage ratio (Lev), as measured by the ratio of total debt to total assets (Firer and Stainbank, 2003), is used to control for the impact of debt servicing on profitability.

3.5 Regression models

The regression analysis consists of four regression equations (models). They explore the relationship between HC, RC, InnC and PrC on the one hand and performance on the other, while controlling also for firm size and leverage:

$$\text{Model 1 : ATO} = \beta_0 + \beta_1\text{HC} + \beta_2\text{RC} + \beta_3\text{InnC} + \beta_4\text{PrC} + \beta_5\text{lnFSize} + \beta_6\text{Lev} + \varepsilon$$

$$\text{Model 2 : ROA} = \beta_0 + \beta_1\text{HC} + \beta_2\text{RC} + \beta_3\text{InnC} + \beta_4\text{PrC} + \beta_5\text{lnFSize} + \beta_6\text{Lev} + \varepsilon$$

$$\text{Model 3 : ROE} = \beta_0 + \beta_1\text{HC} + \beta_2\text{RC} + \beta_3\text{InnC} + \beta_4\text{PrC} + \beta_5\text{lnFSize} + \beta_6\text{Lev} + \varepsilon$$

$$\text{Model 4 : ROI} = \beta_0 + \beta_1\text{HC} + \beta_2\text{RC} + \beta_3\text{InnC} + \beta_4\text{PrC} + \beta_5\text{lnFSize} + \beta_6\text{Lev} + \varepsilon$$

3.6 Data source

Sample firms' data were obtained mainly from the Thomson Reuters – Datastream database and to a lesser extent from the firms' balance sheets and income statements found on their websites. The sample is composed of 18 international seed and agrochemical companies observed over a five-year period, with a total of 90 firm-year observations. The reason for choosing this period is that the data required for the study were fully available for these years only.

4. Results

4.1 Descriptive statistics and correlation analysis

Table II presents the means, standard deviations, minimum and maximum values for all the variables.

Table III presents Pearson pair wise correlation results for the dependent and independent variables for an initial exploration of their relationships. Correlation analysis also helps detect the presence of multicollinearity among explanatory variables. According to Kennedy (1985) multicollinearity should be considered a

Table II. Descriptive statistics for all study variables

Variable	Mean	SD	Minimum	Maximum
ATO	0.928	0.503	0.340	2.360
ROE	0.148	0.120	−0.091	0.853
ROI	0.082	0.053	−0.050	0.210
ROA	0.067	0.061	−0.035	0.478
HC	0.540	0.497	0.027	2.456
RC	0.165	0.084	0.032	0.412
InnC	0.031	0.030	0.000	0.127
PrC	0.272	0.157	−0.020	0.660
Fsize	6.323	2.066	3.190	10.700
Lev	0.200	0.227	0.000	0.793

Note: $n = 90$ firm-year observations

Table III. Correlation analysis of dependent and independent variables

Var	ATO	ROA	ROE	ROI	HC	RC	InnC	PrC	FSize	Lev
ATO	1									
ROA	0.076	1								
ROE	0.143	0.921**	1							
ROI	0.052	0.687**	0.692**	1						
HC	−0.118	−0.141	−0.110	−0.119	1					
RC	0.186	0.290*	0.257*	0.279**	−0.429**	1				
InnC	−0.286**	−0.050	−0.109	0.158	0.101	0.127	1			
PrC	−0.081	0.543*	0.475**	0.763**	−0.001	0.030	−0.249*	1		
Fsize	0.292**	−0.021	0.093	0.130	0.507**	0.261*	0.300**	0.268**	1	
Lev	0.288**	−0.308**	−0.126	−0.305**	−0.040	−0.117	−0.086	−0.0	0.373**	1

Note: *,**Significant at 5 and 1 per cent levels, respectively

serious concern only if the correlation between predictors exceeds 0.8. As shown in Table III, the correlation coefficients between explanatory variables range from a low of 0.001 to a high of 0.507.

Results indicate that RC is positively and significantly correlated with the ROE, ROI and ROA ratios. InnC is negatively and significantly correlated with the ATO ratio. PrC is shown to have a significantly positive correlation with ROA, ROE and ROI. Noticeably, HC is the only IC component that is not significantly correlated with any performance measures. This is an intriguing outcome, which resonates with prior empirical evidence (Cabrita and Bontis, 2008; Cabrita *et al.*, 2007; Costa *et al.*, 2014; Reed *et al.*, 2006; Subramaniam and Youndt, 2005; Veltri and Silvestri, 2011) indicating that HC may affect firm performance indirectly through its impact on the other components of IC. Accordingly, we decided to test whether HC has a moderating effect on the relation between InnC, PrC and RC on the one hand and firm performance on the other. A moderating effect is defined as a third variable's effect that changes the relationship between two related variables (see, e.g. Hair *et al.*, 2006). Thus, we propose three sub-hypotheses to *H1*:

H1a. HC moderates the relation between InnC and firm performance.

H1b. HC moderates the relation between RC and firm performance.

H1c. HC moderates the relation between PrC and firm performance.

To test these sub-hypotheses, we added three interaction terms to our multivariate models. As common in models with interaction terms, we mean-centred the IC variables to minimize the effect of any multicollinearity among the variables comprising our interaction terms (see Venkatraman, 1989). When the moderating effect of HC is considered, the regression models are given by:

$$\begin{aligned}\text{PERF} = {} & \beta_0 + \beta_1\text{HC} + \beta_2\text{RC} + \beta_3\text{PrC} + \beta_4\text{InnC} \\ & + \beta_5\text{HC}\times\text{InnC} + \beta_6\text{HC}\times\text{PrC} + \beta_7\text{HC}\times\text{RC} + \varepsilon\end{aligned}$$

4.2 *Hypotheses verification and discussion*

Tables IV-VII present the results of the regression models for each performance characterization (ATO, ROA, ROE and ROI, respectively). Each regression model was tested in two steps: first we estimated solely the direct effect of each variable (*H1-H4*), then we tested the moderating-effect hypotheses (*H1a-H1c*) by including the interaction terms.

Dependent variable: ATO Independent variables	Direct-effect model Standardized coefficient β	VIF	Direct and interaction effect model Standardized coefficient β	VIF
Direct effects				
HC	−0.299**	1.793	−0.222	1.993
InnC	−0.467***	1.239	−0.461***	1.240
PrC	−0.164	1.200	−0.116	1.279
RC	0.306**	1.300	0.282**	1.319
Controls				
FSize	0.709***	2.215	0.681***	2.240
Lev	−0.004	1.429	−0.039	1.491
HC interaction effects				
HC × InnC			0.196*	1.289
HC × PrC			0.026	1.708
HC × RC			0.387	5.684
Adj R^2	0.405		0.430	
ΔAdj R^2			0.025	
F	11.087***		10.589***	

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Table IV.
Regression results – model 1: ATO and IC components

Dependent variable: ROA Independent variables	Direct-effect model Standardized coefficient β	VIF	Direct and interaction effect model Standardized coefficient β	VIF
Direct effects				
HC	−0.084	1.793	−0.039	1.993
InnC	−0.286***	1.239	−0.0283**	1.240
PrC	0.541***	1.200	0.570***	1.279
RC	0.277**	1.300	0.263**	1.319
Controls				
FSize	0.155	2.215	0.139	2.240
Lev	−0.324***	1.429	−0.298**	1.491
HC interaction effects				
HC×InnC			0.116	1.289
HC×PrC			−0.100	1.708
HC×RC			−0.093	5.684
Adj R^2	0.460		0.465	
ΔAdj R^2			0.005	
F	13.649***		12.049***	

Notes: $**p < 0.01$; $***p < 0.001$

Table V.
Regression results – model 2: ROA and IC components

It is should be noted that all four baseline models (i.e. models without interaction terms) display the highest statistical significance ($p < 0.001$) and a reasonably good explanatory power, with adjusted R-squared values ranging from 35 to 71 per cent. These latter did improve slightly when the interaction terms were included in the analysis.

An additional test for multicollinearity was conducted by estimating the variance inflation factors (VIF). Using a fairly conservative cut-off value of VIF = 3 relative to

Dependent variable: ROE Independent variables	Direct-effect model Standardized coefficient β	VIF	Direct and interaction effect model Standardized coefficient β	VIF
Direct effects				
HC	−0.089	1.793	−0.026	1.993
InnC	−0.350***	1.239	−0.345***	1.240
PrC	0.469***	1.200	0.508***	1.279
RC	0.296**	1.300	0.277**	1.319
Controls				
FSize	0.265*	2.215	0.243*	2.240
Lev	−0.191	1.429	−0.155	1.491
HC interaction effects				
HC × InnC			0.160*	1.289
HC × PrC			0.082	1.708
HC × RC			0.032	5.684
Adj R^2	0.351		0.365	
ΔAdj R^2			0.014	
F	9.030***		8.301***	

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Table VI. Regression results – model 3: ROE and IC components

Dependent variable: ROI Independent variables	Direct-effect model Standardized coefficient β	VIF	Direct and interaction effect model Standardized coefficient β	VIF
Direct effects				
HC	−0.134	1.793	−0.089	1.993
InnC	−0.133*	1.239	−0.130*	1.240
PrC	0.702***	1.200	0.731***	1.279
RC	0.240***	1.300	0.226**	1.319
Controls				
FSize	0.236**	2.215	0.220***	2.240
Lev	−0.332***	1.429	−0.307***	1.491
HC interaction effects				
HC × InnC			0.114*	1.289
HC × PrC			−0.012	1.708
HC × RC			−0.267	5.684
Adj R^2	0.710		0.718	
ΔAdj R^2			0.008	
F	37.362***		33.318***	

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Table VII. Regression results – model 4: ROI and IC components

recommended values of 5 or 10 (e.g. Craney and Surles, 2002), no serious concern of multicollinearity among predictors was detected across all models.

As far as the direct-effect hypotheses are concerned (*H1-H4*), we found that: first, the coefficient on HC is negative across all models and statistically significant only in the ATO model; second, the coefficients on InnC are highly significant across all models but in the opposite direction than expected; third, the coefficients on PrC are positive and significant in three models out of four; and fourth, all coefficients on RC are positive and statistically significant.

Overall then, the results of testing the direct effects of IC variables support only *H3* and *H4*. Most notably, RC as measured by SG&A has a direct, positive and statistically significant effect on all performance measures. Arguing in line with Cheng *et al.* (2010), we might infer that companies that do better in terms of profitability often have large budgets for developing and nurturing their RC. In the setting of agribusiness companies, advertising, promotion and distribution are the major input costs of maintainable customer relationships. Advertising and promotion are necessary to position a firm's product relative to competitors' offerings, to educate dealers or contract growers on the best crop management practices and to induce farmers to adopt the firm's particular seed varieties and chemical companion (e.g. through customer incentive programmes). Distribution costs include costs of transportation and communication between production facilities, wholesalers, retailers and farmers. All such costs (included in the SG&A line item) can be thought of as investments in the firm's customer base, brand reputation and distribution capacity, which collectively comprise and enhance its "relational capital".

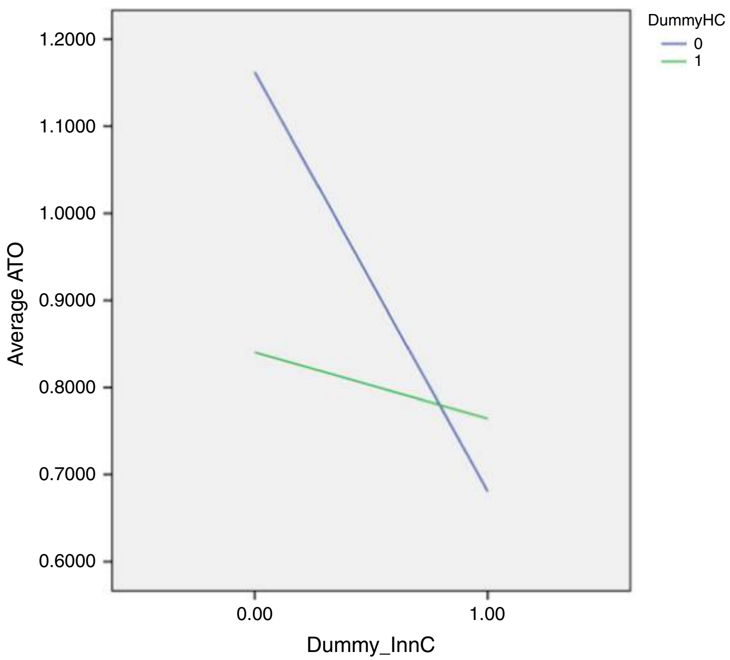
Also consistent with our predictions (*H3*), the coefficients on PrC are positive and significant, except for the model 1. This would suggest that PrC (as measured by the fixed-assets-turnover ratio) is a significant predictor of economic and financial performance for our sample firms. This outcome is line with prior empirical evidence indicating that companies with higher fixed-asset-turnover have better earnings performance (e.g. Wang and Chang, 2005).

Contrary to a priori expectations (*H2*), InnC shows a significantly negative impact on performance across all models. The negative sign on InnC might be due to the fact that R&D investments take a long time to pay off (Barker, 1999; Ferraro and Veltri, 2011; García-Meca and Martínez, 2007), which is especially true in the seed industry, for instance, due to extensive regulatory and legislative requirements that affect the development, manufacture and distribution of new products (e.g. obtaining and maintaining permits for testing and planting new seed varieties containing new biotechnology traits or distribution rights can be time-consuming and costly with no guarantee of success). Moreover, under conservative accounting practices, research expenses as well as costs incurred to internally develop new crop protection products or new seed varieties that have not yet obtained regulatory approval, are expensed as incurred because of the uncertainty inherent in the outcome of the regulatory approval process. By the same token, costs of defending existing patents and costs of challenging patents held by third parties are often charged to development expenditures and expensed as incurred.

All such considerations might explain our finding that R&D investments adversely affect corporate performance. However, the analysis of the moderating effects of HC provides further insight on the relation between InnC and performance.

Indeed, the key finding pertaining to the moderating-effect hypotheses (*H1a*-*H1c*) is that HC positively moderates the relation between InnC and performance – the coefficient on the HC × InnC term is positive and statistically significant in three models out of three – which suggests that firms with high levels of HC are better placed to gain returns from R&D investments than firms with lower HC levels. This appears to lend to support for *H1a*. Instead, the HC-RC interaction (*H1b*) and the HC-PrC interaction (*H1c*) are not significant in any of the regression models.

Because the interpretation of interaction terms solely from regression coefficients can be misleading (Aiken and West, 1992), Figures 1-4 plot the interaction effect of HC and InnC on firm performance for each performance characterization.



Notes: The IC components depicted in Figure 1 represent bifurcated variables. High values for each component were calculated by equating all values above the mean to 1. Low values were calculated by equating all values below or at the mean to 0

Figure 1.
Interaction effect of human and innovation capital on ATO

To generate the graphs, each IC component was split into a dummy variable (0, 1) where values above the mean were considered high (equal to 1) and values at or below the mean were considered low (equal to 0). The resulting figures show that the impact of InnC on firm performance is contingent upon the level of HC investments. That is, the impact of R&D investments on performance is negative for lower values of HC investments while it becomes positive (or less negative) for higher levels of HC. A likely explanation is that firms which heavily invest in HC manage to attract and retain highly skilled and talented people, thus they are better placed to leverage their R&D investments because highly talented workers have a lower cost of learning, and absorb more knowledge than less-talented ones, especially in R&D-intensive firms (see Møen, 2005). In turn, the more a firm invests in R&D, the more it may be increasing the ability of knowledge workers to absorb new knowledge (i.e. its HC) as contended by organizational learning theorists (e.g. Cohen and Levinthal, 1990).

4.3 Control variables

Turning to the control variables, the sign of the leverage variable is always negative and statistically significant in two models out of four (namely, in the ROA and ROI models). This would suggest that more profitable agribusiness companies use less debt capital, as they have more internal finance to rely on. The coefficient on firm size is positive and statistically significant in three models out of four (ATO, ROE and ROI models). A feasible explanation

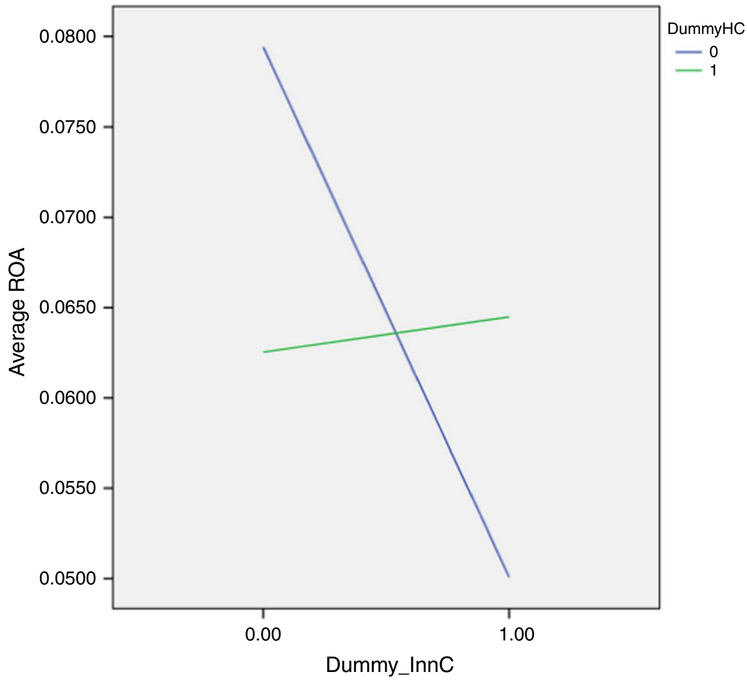


Figure 2.
Interaction effect of human and innovation capital on ROA

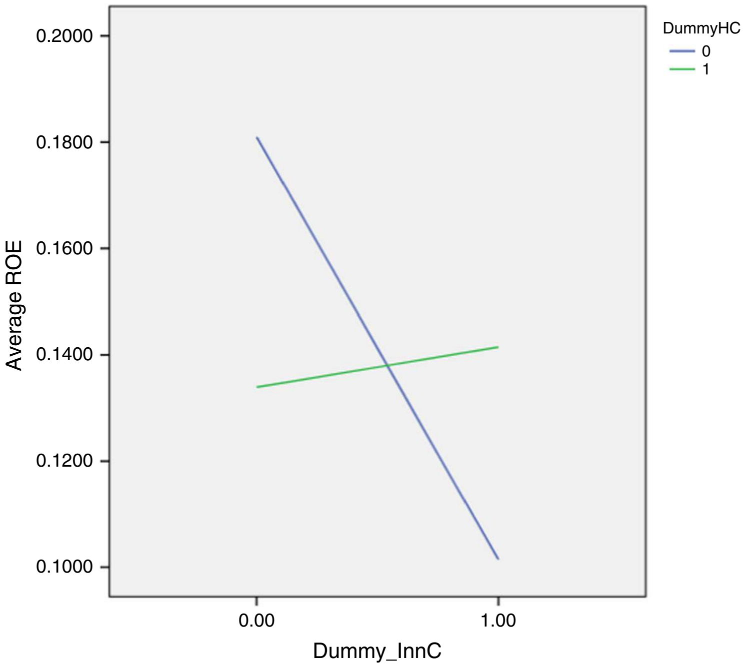
Notes: The IC components depicted in Figure 2 represent bifurcated variables. High values for each component were calculated by equating all values above the mean to 1. Low values were calculated by equating all values below or at the mean to 0

is that large agribusiness companies – many of them are multinational conglomerates – enjoy scale economies to offset the high costs of biotechnology R&D as well as marketing and distribution costs. Additionally, agribusiness giants benefit from strong demand complementarities as they operate both in the seed and agrochemical markets.

5. Research implications and conclusions

The findings of this study suggest several implications for research and practice. First, this study intends to contribute to the measurement stream of IC research by further developing and validate a set of operational measures adapted from prior research studies as a way to infer IC from easily accessible data. Second, it provides new evidence on the relationship between IC and performance using the agribusiness industry as a research setting, which is characterized as highly knowledge-intensive and thus offers an ideal and somewhat novel context for the analysis.

The test for the moderating effect of HC also extends prior research showing that the link of HC to performance becomes substantive and significant only when it interrelates with the other types of IC. In this instance a significant interaction effect of HC and InnC was found on performance. In terms of managerial implications this finding suggests that HC and InnC should be viewed in tandem as complementary resources, such that a coordinated investment strategy could result in a distinctive resource endowment, which in turn should positively impact firm performance. This resonates



Notes: The IC components depicted Figure 3 represent bifurcated variables. High values for each component were calculated by equating all values above the mean to 1. Low values were calculated by equating all values below or at the mean to 0

Figure 3. Interaction effect of human and innovation capital on ROE

with the view that IC is a phenomenon of interactions and complementarities (Bollen *et al.*, 2005; Cabrita and Bontis, 2008; Cabrita *et al.*, 2007) implying that the value of one type of IC can be leveraged through investments in other types (Reed *et al.*, 2006). While we have to be cautious to generalize these findings to other industry sectors it seems that at least in the agribusiness industry HC and InnC as investment priorities to high levels may result in superior performance.

Eventually this study might also contribute to the specific literature that has focused on the relation between R&D and firm performance, as it uncovers that the value-generating effect associated with R&D investments is contingent on the levels of HC. This may provide a fruitful insight to this strand of research, especially given that only a few studies (e.g. Banker *et al.*, 2009; Ferraro and Veltri, 2011) have examined how and whether HC moderates the relation between R&D and firm performance.

6. Research limitations and future directions

This study is however not without limitations. The main obvious limitation is inherent in the use of accounting figures which can realistically be only imperfect proxies for the theoretical variables of interest. Second, we approximate each IC pillar by a single indicator which at best can only partially capture the targeted construct. It should be noted however that to date there are still no perfect solutions available for measuring IC due to the lack of a widely accepted measurement theory for IC (Nazari and Herremans, 2007).

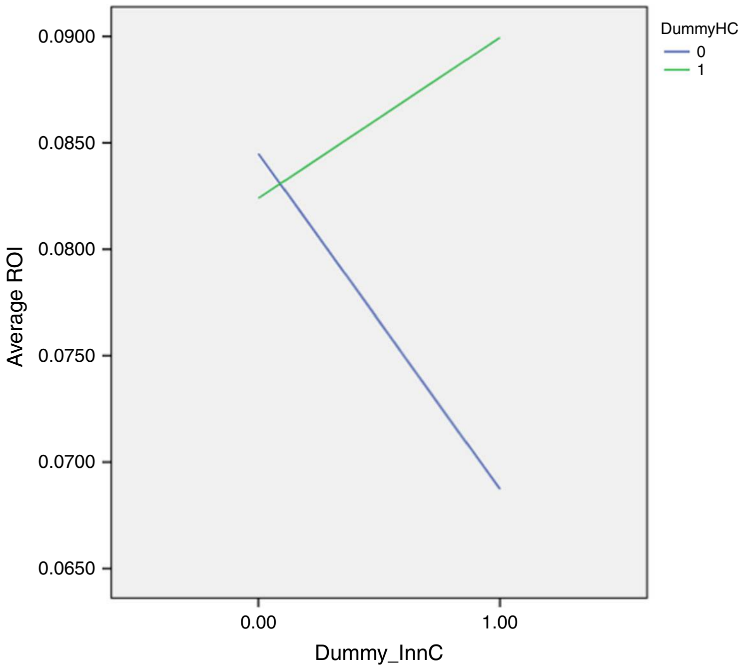


Figure 4. Interaction effect of human and innovation capital on ROI

Notes: The IC components depicted in Figure 4 represent bifurcated variables. High values for each component were calculated by equating all values above the mean to 1. Low values were calculated by equating all values below or at the mean to 0

A third inherent limitation of this study is that it focuses only on seed and agrochemical companies. Hence, an advance to this study could lie in its extension to other research-intensive industries in order to find out whether the results hold true for a more diversified sample. Besides, future research should be conducted over a sample that spans a longer time period, which was not possible in this case because the data needed for the analysis were fully available and consistent only for the five-year period under investigation.

Future research should consider using more advanced statistical techniques such as structural equation modelling, which provides a better solution to the statistical testing of the interrelationships among IC components and their "cumulative" impact on performance.

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