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# Intellectual Capital Investments: Evidence from Panel VAR Analysis

Purpose. Investments in intellectual capital (IC) are often linked to competitive advantages that improve economic profit and increase the value of a company. However, this effect is reciprocal: Companies that generate higher cash flow can invest more in intellectual capital. The aim of this study is to analyze a dynamic relationship between IC components and economic profit, with a special emphasis on industry specific effects in pharmaceutical, retail, steel, telecommunications, and service sectors.

Design/methodology/approach. Panel vector autoregression (VAR) was used to deal with the mutual influence of intellectual capital components, the lag effect, and heterogeneity. The data was taken from Compustat database and covers the period from 2001 to 2010.

Findings. This research proves that there is interaction between investments in the IC components and company performance. However there are sectoral differences: there is a positive impact of economic profit on human capital in retail; in the steel industry a mutual influence is revealed. Moreover, interaction between different IC components is detected in telecommunication and steel industries.

Originality/value. This is the first study to present clear evidence of the effects of performance on IC investment decisions. The time lag in the effects of IC investments was estimated and compared for different industries. On the methodological side, the paper presents a rather simple method capable of yielding results consistent with other studies and yet rich enough to be applied to an analysis of sectoral differences in dynamic IC investment decisions.

## 1. Introduction

Nowadays the increasing in the importance of the intellectual resources of companies is confirmed by empirical studies and is recognized in the business world (Lev, 1999). Consequently, the financial performance of a company and its equity attractiveness for potential shareholders are also largely driven by its intellectual capital. However, the means by which investment in intellectual capital actually allows companies to achieve success is a debatable question. So, if a company invest some funds in intellectual resources and expects them to create a competitive advantage, managers should measure the return on them.

Intellectual capital theory considers such key companies' resources as employee knowledge, information systems, relationships with suppliers and customers, and management. It combines existing achievements in different areas, such as intangible asset evaluation, theory of competitive advantage, resource-based approach to the theory of the firm, and human capital. It also disseminates approaches to human capital analysis to other types of intellectual capital.

There are three levels of intellectual capital analysis – macro level, sectoral level and micro level – and in the present paper intellectual capital is considered at the company level.

Nowadays, the role of intellectual capital in corporate management is being actively investigated. A number of empirical studies show that the contribution of intellectual resources in a company's value is significant (Bontis et al., 2000; Chen et al, 2004; Tseng and Goo, 2005; Huang and Hsueh, 2007; Kamukama et al., 2010; Chang and Hsieh, 2011). A company's intellectual capital is heterogeneous and is usually divided into several components. So the interaction between these components is also of interest to researchers. A feature that should be noted is a theoretically possible delay between the impacts of one intellectual component on performance or others components (Tseng and Goo, 2005; Kaplan and Norton,1992; Chen et al., 2004). Although this delay is recognized theoretically, empirical investigations usually ignore it in regression analysis.

Thus, researchers recognize a company's intellectual resources as being crucial for survival and for successful competition in the knowledge economy. However most of these studies are based on the assumption that the impact is completely exhausted in one period, while theoretical assumptions run to the contrary. Moreover, these studies ignore the following inverse direction of relationship: Company performance (earnings or economic profit) is closely connected with a company's ability to invest, which in turn causes the growth of intellectual resources. Consequently, in models that do not take into account the reverse effect, there is some endogeneity, which biases the model's evaluation results towards giving a higher importance to intellectual capital. In the present paper it is attempted to solve this problem as reasonable a way as possible, and in addition to that to take into account the mutual influence of intellectual resources and their relationship with a company's tangible resources.

The remainder of the paper is organized as follows. Section I provides the theoretical background on intellectual capital, its structure and features. Section II describes sample selection, variables, research model and method of analysis. Section III presents the results of this research that are discussed further in Section IV.

## 2. Literature review

There is no precise agreement on the definition of intellectual capital, but the majority of authors points out that it helps a company to compete. Some authors include this feature just in definition of intellectual capital: *"Intellectual capital is intellectual material-knowledge, information, intellectual property, experience, that can be put to use to create wealth" (Stewart, 1997).* So the existence of a relationship between intellectual capital and a company's wealth

seems to be obvious. Although it is still a point at issue how intellectual capital can be converted into company wealth.

This wealth creation process can be illustrated by the input-output-outcome concept (Cheng et al., 2010; Molodchik et al., 2012). Intellectual capital is treated as part of the resources (input) that a company invests in order to gain competitive advantage and to improve performance (output) which then causes an increase in company value (output). However papers based on company value miss a lot of information about companies which are not listed on a stock exchange. This study is focused on the first stage, that is, the transformation of intellectual resources into company performance.

Intellectual capital is generally recognized as not being a one and indivisible company resource, and for investigation purposes it is usually subdivided into several components. Following previous studies in this field, three main structural components of intellectual capital are identified: Human capital, structural capital, and relational capital (Bontis et al., 2000; Bontis, 1996, 1998, 1999; Roos et al., 1998; Stewart, 1991, 1997; Sveiby, 1997; Edvinsson and Malone, 1997; Edvinsson and Sullivan, 1996; Moon and Kym, 2006; Nazari, 2010).

- **Human** capital. In the concept of intellectual capital, human capital is treated as knowledge that belongs to employees, for example skills, abilities, and experience (Stewart, 1997; Lee, 2011).
- **Structural** capital is defined as "the knowledge that doesn't go home at night" (Stewart, 1997). Although it is created by employees, it can also be separated from them. First of all, structural capital includes organizational procedures, strategies, patents, manuals, and databases (Nazari, 2010). In other words, structural capital is determined by human capital, but at the same time it is independent.
- **Relational** capital is a company's ability to interact successfully with its external stakeholders in order to develop the potential of value-creation by enhancing human and structural capital.

Theoretical models of intellectual capital such as Scandia Navigator (Edvinsson and Melone, 1997) describe the interaction between various intellectual capital components. Empirical research usually confirms the idea that dimensions of intellectual capital are interrelated (Chang and Hiesh, 2011; Huang and Wu, 2010; Carbita et al., 2006; Kamukama et al., 2010; Bontis et al., 2000; Tseng and Goo, 2005).

Table 1 combines the hypotheses and findings of previous papers on the relationships between intellectual capital components and company performance. The common idea is that intellectual capital creates competitive advantage for a company so it should contribute to the

company's performance (Chang and Hiesh, 2011; Huang and Wu, 2010; Carbita et al., 2006; Kamukama et al., 2010; Bontis et al., 2000; Tseng and Goo, 2005; Dı´ez et al., 2010). It should be noted that although the research question is roughly the same, the results are contradictory. For example, some authors found that there is direct influence of human capital on performance (Chang and Hiesh, 2011; Huang and Wu, 2010; Cheng et al., 2010), while other papers have contrary results (Bontis et al., 2000; Carbita et al., 2006). Thus further research is required.

**Table 1. Prior studies investigating the relationship between of intellectual capital components and performance**

| Study | Country and period | Dependent variables | Hypotheses | Results |
|---|---|---|---|---|
| Chang and Hsieh (2011) | Technology companies listed in Taiwan Stock Exchange, 2001-2007 | HC - Human Capital;<br>SC - Structural Capital;<br>CE - Social Capital;<br>TC - Technological Capital;<br>HC, SC, CE, TC – VAIC model components.<br>MP - market performance (Tobin q). | 1: HC, SC, CE and TC positively affect MP.<br>2: HC mediates the relationships between SC, CE, TC and MP.<br>3: HC moderates the relationships between SC, CE, TC and MP. | Statistics supports a mediating/moderating effect of HC on CE and SE of organizations. |
| Huang and Wu (2010) | Taiwan biotechnology industry (TBI) and Taiwanese pharmaceutical manufacturers, 2005 | HC - Human Capital;<br>OC - Organizational Capital;<br>SC - social capital;<br>KP - knowledge productivity.<br>HC, OC, SC, KP – data obtained from questionnaires. | 1: The greater HC, the higher the KP.<br>2: The greater OC, the higher the KP.<br>3: The greater SC, the higher KP.<br>4: The greater SC, the stronger the influence of HC on KP.<br>5: The greater SC, the stronger the influence of OC on KP. | All dimensions of intellectual capital positively and significantly influence KP.<br>The study proves there are interactive effects between the components of intellectual capital and KP. |
| Carbita and Vaz (2006) | 53 banks, all affiliated members of the Portuguese Bankers Association | HC - Human capital;<br>SC - Structural capital;<br>RC - Relational capital;<br>OP - Organizational | 1: HC is positively associated with SC;<br>2: HC is positively associated with RC;<br>3: SC is positively associated with RC;<br>4: SC is positively associated with OP; | Significant effects indicate direct and indirect relationships between intellectual capital components and OP.<br>SC and RC positively moderates the |

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| | | performance;<br>HC*SC*RC - interaction term.<br>HC, RC, SC, OP – data obtained from questionnaires. | 5: RC is positively associated with OP;<br>6: The relationship between HC and OP is positively moderated by the interaction between SC and RC. | relationship between HC and OP. |
| Kamukama, Ahiauzu, and Ntayi (2010) | 65 Ugandan microfinance institutions, 2009/2010 | HC – Human capital;<br>SC - Structural capital;<br>RC - Relational capital;<br>FP - Financial performance;<br>HC, RC, SC, FP – data obtained from questionnaires. | 1: HC positively affects FP.<br>2: SC positively affects FP.<br>3: RC positively affects FP.<br>4: HC influences FP if it interacts with RC.<br>5: HC influences FP if it interacts with SC.<br>6: SC influences FP if it interacts with RC. | The magnitude effect of HC on FP depends on any of SC or RC; hence the assumption of nonadditivity is met. No significant interaction effects were established between RC and SC. |
| Bontis, Keow, and Richardson (2000) | 107 Malasyan firms from service and non-service industries | HC – Human capital;<br>SC - Structural capital;<br>CC - Customer capital;<br>FP - Financial performance;<br>HC, RC, SC, FP – data obtained from questionnaires. | 1: HC positively associated with CC.<br>2: HC associated with SC.<br>3: CC positively associated with SC.<br>4: SC positively associated with FP. | HC is important regardless of industry type; HC has a greater influence on how a business should be structured in non-service industries compared to service industries; CC has a significant influence over SC irrespective of industry; the development of SC has a positive relationship with business FP regardless of industry. |
| Tseng, Goo (2005) | 500 largest (in terms of sales revenues) Taiwanese Manufacturers | INC - Innovation capital;<br>OC - Organizational capital;<br>RC - Relationship capital;<br>HC – Human capital;<br>V – Corporate | 1: INC positive affects V.<br>2: OC positively affects V.<br>3: RC positively affects V.<br>4: HC positively affects INC.<br>5: HC positively affects OC. | HC and OC indirectly and positively influence V.<br>INC and RC directly and positively impact V.<br>HC has a high degree of interaction with other three |

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|---|---|---|---|---|
| | | value: M/B, Tobin'Q and VAIC<br>HC, OC, RC, INC – data obtained from questionnaires. | 6: HC positively affects RC.<br>7: OC positively affects INC.<br>8: OC positively affects RC.<br>9: INC positively affects RC. | types of IC.<br>OC also positively influences on INC and RC.<br>INC positively affects RC.<br>Effect of IC on enhancing V in Hightech companies more than in Non-high-tech companies. |
| Dı´ez, Ochoa, Prieto, and Santidria´n (2010) | 211 Spanish firms, 2007 | HC – Human capital;<br>SC - Structural capital;<br>V – Corporate value: Sales Growth, productivity and return on assets.<br>HC, SC – data obtained from questionnaires. | 1: HC positively affects V.<br>2: SC positively affects V. | The study confirms the positive relation between the use of HC and SC indicators, and V measured by sales growth.<br>Higher levels of the VAIC, in particular for the component that refers to the sum of the coefficient of HC and SC, are also related to improvements in V.<br>Productivity and return on assets do not showed significant results. |
| Cheng, Lin, Hsiao, and Lin (2010) | 224 samples from 56 UK health care companies spanning the period 2002-2005 | INN - Innovative capacity,<br>CUS - maintainable customer relationship costs,<br>HUM - human value added,<br>PRO - Efficient operating processes,<br>PER - corporation's performance | H1a. INN has a positive correlation with CUS.<br>H1b. INN has a positive correlation with HUM.<br>H2. PRO reduce CUS.<br>H3. HUM is positively correlated with CUS.<br>H4a. The higher CUS, the higher the positive effect on the PER.<br>H4b. The higher the HUM, the higher the positive effect on PER. | Significant relationship between intellectual capital and company performance. These results also suggest that INN and process reformation shall be considered first, and through the HUM of human capital, firms can improve PER. |

Some authors also assume that there is a certain inertia which delays total and immediate use of benefits derived from intellectual capital investments. This is what Tseng and Goo call «effect of time delay» (Tseng and Goo, 2005). This means that investments in human, relational, and structural capital take time to be fully implemented: In general, this property is common to all types of investment, but taking it into consideration, it shows the need to consider the return on investment in human capital with a certain lag. Norton and Kaplan emphasize this feature in the construction of the Balanced Scorecard (Kaplan and Norton, 1992). They call operational indicators, such as customer satisfaction and relationships with suppliers, "leading" or "factors of activity", while they consider financial indicators to be "lag indicators". Chen et al. also mentioned this effect, explaining the relatively low correlation between two intellectual capital components (Chen et al., 2004).

According to the literature on the relationship between investments and company performance, earnings are the determinant of investments (Love and Zicchino, 2006; Eklund, 2010). Consequently inverse direction on influence should exist: company performance affect on investments in intellectual resources. Moreover in investment decision making process management take into consideration the stability of earnings. So company performance in current years may affect on future investments.

Considering all of the above, the following hypotheses are proposed:

H1. Investments in intellectual capital components are associated with each other.

H2. Investments in intellectual capital components positively affect company performance for a period of more than one year.

H3. Company performance positively affects investments in intellectual capital components.

Measurement is the principal issue in empirical studies on intellectual capital. Sveiby suggests four categories of measurement methods to intellectual capital (Sveiby, 2001): Direct Intellectual Capital methods (DIC), Market Capitalization Methods (MCM), Return on Assets methods (ROA), Scorecard Methods (SC). ROA methods are based on performance indicators such as economic value added or earnings. So, they can be used to assess the return on intellectual capital investments (output measures), but are inappropriate for measuring investments in intellectual capital. DIC methods measure the values of intellectual resources by identifying various components. SC methods imply the creation of a system of indices and indicators that can report company's intellectual capital in a scorecard or graph. Following this classification DIC methods are relevant for measuring input factors (investments in intellectual capital).

In empirical research three main approaches to measure intellectual capital components can be distinguished. Firstly, authors generally use questionnaires to estimate the amount of intellectual capital (Huang and Wu, 2010; Carbita et al., 2006; Kamukama et al., 2010; Bontis et al., 2000; Tseng and Goo, 2005; Dı´ez et al., 2010). Secondly, components of VAIC model are frequently used (Firer and Williams, 2003; Chen et al., 2004; Chan, 2009). Thirdly, intellectual capital components are approximated with proxy indicators (Huang and Liu, 2005; Cheng et al., 2010; Shakina and Barajas, 2012). The latter approach is similar to the first one to some extent: the measurement is based on evaluation of separated intellectual resources.

The output of investments in intellectual capital also can be measured in several ways. As for the intellectual capital components, authors obtain indicators of company performance through interviewing employees and top managers (Huang and Wu, 2010; Carbita et al., 2006; Kamukama et al., 2010; Bontis et al., 2000; Dı´ez et al., 2010). Also one of the common approaches in performance measurement is the using of financial performance indicators: Return on Assets (Firer and Williams, 2003; Chen et al., 2005; Chan, 2009; Cheng et al., 2010), Return on equity (Cheng et al., 2010), and Asset Turnover (Firer and Williams, 2003; Chen et al., 2005; Chan, 2009).

Also it should be noted that the terms “intellectual capital” and “intangibles” are not treated as synonymous in this paper. For the purposes of the current study the authors use the term “intangibles” for balance sheet item “Intangibles” only in order to avoid misunderstanding.

# 3. Data

In order to evaluate the impact of intellectual capital on a company’s performance, it is necessary to determine an indicator for each intellectual capital component. At the same time, since it is necessary to take into account the delayed impact of investment in intellectual capital, indicators inherent in dynamics are needed. The measure of human capital (HC) will be the number of company employees (Edvinsson and Malone, 1997; Baiburina and Golovko, 2008; Garanina, 2009; Sullivan, 2000; Wang and Chang, 2005; Zickgraf et al., 2007). This indicator characterizes the number of “carriers” of this component of intellectual capital and it is known to external investors. On the other hand, this indicator has a disadvantage in that it ignores differences in employee knowledge that depend on their position in the company.

The proxy indicator of a company’s structural capital (SC) can be represented by the balance sheet value of its intangible assets (Shakina, 2011; Shakina and Barajas, 2012), since this is an estimate of the value of its patents and licenses. In this case, intangible asset value fails to

include many elements of structural capital, such as manuals, know-how, and corporate culture because the information about them is available only to internal stakeholders. However, in this paper it is assumed that the intensity of use for these structural capital elements is proportional to the intangible assets value, as specified in the balance sheet. In this case, the intangible assets value can be a proxy indicator for structural capital owned by the company.

In empirical studies Relational Capital (RC) is usually measured by an indicator calculated on the basis of a company's revenue (Bassi and Van Buren, 1999; Brennan and Connell, 2000; Tsan, 2004; Chen, 2004; Marr and Adams, 2004) or advertising expenditures (Edvinsson and Malone, 1997; Tsan, 2004; Wu, 2004; Chen, 2004). However, these indicators characterize a company's relationship only with customers and do not reflect the part of a company's value created through relationships with suppliers. A company's contribution to the development of relational capital can be estimated as the excess of accounts receivable over accounts payable. The larger this value is, the greater deferral a company offers to its clients and the quicker it pays for supplier goods and services.

Also it is necessary to consider that tangible assets (TA) are required for a company's activity and may affect financial performance.

In order to make a cross-industry comparison, a group of major industries that play an important role in the US economy was selected. Each industry can be characterized by some specific features that are related to the role of intellectual capital.

- The pharmaceutical industry is mainly characterized by significant structural capital value, represented by licenses and patents.
- Consulting and educational services were attributed to the service industry. Thus, the key resource for this industry is human capital and established relationships with customers.
- The steel industry is generally classified as one of the traditional industries. Steel companies have minor amounts of intellectual capital.
- The retail industry is characterized by small amounts of tangible assets. The most important role here is the attraction of customers, which is viewed as relational capital.
- The telecommunications industry, like the retail trade, is mostly focused on the attraction and retention of customers. Furthermore, the development of communication facilities and customer databases requires investments in structural capital.

Table 1 contains information on the value of different components of intellectual capital relative to tangible assets. Selected proxy indicators reflect the expected economic characteristics of the various industries.

**Table 2. A comparison of industries on the relative size of intellectual capital components.**

| | Number of observations | HC/TA | SC/TA | RC/TA |
|---|---|---|---|---|
| Pharmaceutical | 1035 | 0.09 | 10.47 | -7.20 |
| Retail | 1080 | 0.06 | 1.82 | -1.68 |
| Services | 1222 | 0.36 | 6.82 | -6.85 |
| Steel industry | 390 | 0.02 | 0.28 | -0.50 |
| Telecommunications | 1727 | 0.04 | 3.33 | -1.19 |

Empirical studies regarding the influence of intellectual capital on a company's activity use different measures of performance. Short-term indicators measure performance over one period, such as return on assets (Firer and Williams, 2003; Chen et al., 2004; Shiu, 2006; Ting, Lean, 2009), return on equity (Chen et al., 2004), operating profit, or EVA (Huang and Wang, 2008). Firstly, one of the traditional measures that could be derived directly from a company's reports – net operating profit (NOPAT). Secondly, economic profit (EVA) is used in accordance with the value-based management concept, and it helps to take into account not only explicit costs, but also opportunity costs. Moreover, it is believed that economic value added better reflects company value creation than operating profit (Stern et al., 2001). EVA is calculated as follows:

$$EVA_{i,t} = NOPAT_{i,t} - WACC_{i,t} \cdot IC_{i,t-1}, \quad (1)$$

where $IC_{i,t-1}$ is the sum of the book values of equity and long-term debt capital, and $WACC_{i,t}$ is the weighted average cost of capital:

$$WACC_{i,t} = k_{e\,i,t} \cdot \frac{E_{i,t}}{V_{i,t}} + k_{d\,i,t} \cdot \frac{D_{i,t}}{V_{i,t}} \cdot (1 - tax_{i,t}), \quad (2)$$

where $D_{i,t}$ is the book value of long-term debt; $E_{i,t}$ is the book value of equity, $tax_{i,t}$ is the effective tax rate of the company; $k_{d\,i,t}$ is the cost of debt determined based on the company's synthetic credit rating as the sum of the risk-free rate and the default spread (found according to S&P ratings); and $k_{e_{i,t}}$ is the cost of equity:

$$k_{e\,i,t} = RF_t + RP_t \cdot \beta_{i,t} \quad (3)$$

$RF_t$ is the risk-free rate, calculated as the geometric mean of the yield of U.S. Treasury bills for 30 years. $RP_t$ is the risk premium associated with changes in the stock market. It is calculated as the difference between the geometric mean for the stock returns in the U.S. stock market for 40 years and the risk-free rate. $\beta_{i,t}$ is the beta coefficient characterizing the company's risks associated with whole economy risks (systematic risks). The unlevered beta coefficient ($\beta_{u\,i,t}$) is obtained from the Damodaran database and then adjusted according the Hamada formula (Damodaran, 2004):

$$\beta_{i,t} = \beta_{u\,i,t} \cdot \left(1 + \frac{D_{i,t}}{E_{i,t}} \cdot (1 - tax_{i,t})\right). \quad (4)$$

The source of the data is Compustat database. The sample contains information about American companies working in pharmaceutical, retail, steel, telecommunications, and service industries for 2001 to 2010. The choice of U.S. companies is justified by the fact that the role of intellectual capital in the U.S. is a significant one, according to the Knowledge Economy Index of the World Bank and the National Intellectual Capital Model (Lin and Edvinsson, 2008), which estimate the overall level of a country's development and the efficiency of its use of knowledge.

# 4. Empirical Methodology

It is challenging to estimate the relationship between components of intellectual capital and a company's performance measures (NOPAT, EVA) because selected variables may simultaneously affect each other. Thus, it is difficult to mark out the impact of one selected factor over another, abstracting from the effects of other variables.

In the present research vector autoregression (VAR) is used for this purpose. The use of orthogonal response functions (impulse response function, hereinafter IRF) helps to solve the problem described above: The reaction of one variable (for example, NOPAT) to a shock in another variable (for example, HC) can be evaluated, leaving all other variables of structural model constant and without considering their changes (shocks).

Panel VAR (panel vector autoregression, hereinafter pVAR) is estimated. It helps to combine the advantages of VAR (all variables can be assumed as endogenous) and the advantages of using panel data, allowing the taking into account of the individual heterogeneity of companies (Love and Zicchino, 2006).

PVAR of a second order is used:

$$z_{i,t} = \alpha + \beta_1 \cdot z_{i,t-1} + \beta_2 \cdot z_{i,t-2} + f_i + e_{it}, \quad (5)$$

where $z_{i,t}$ is a vector of four variables {NOPAT, hc, rc, sc}. Another specification where $z_{i,t}$ = {EVA, hc, rc, sc} is used in order to consider the differences in the relationships between intellectual capital and accounting (NOPAT) and economic (EVA) indicators; $f_i$ is a company's individual features (see below); hc is the increase in the number of employees, measured in thousands; rc is the increase of the difference between accounts receivable and accounts payable, measured in millions of US dollars; sc is the increase in the value of intangible assets, also measured in millions of US dollars; and NOPAT is the net operating profit, calculated on the basis of a company's effective tax rate. NOPAT and EVA are measured in millions of US dollars.

To analyze the impact of one variable shock to another variable an *impulse-response function* (IRF) is applied. However, since the empirical variance-covariance matrix is diagonal, in order to isolate shocks it is necessary to decompose residuals in the model so that they will be orthogonal (this procedure is known as Choleski decomposition) (Love and Zicchino, 2006). Building an IRF is crucial for analysis, it permits to focus on how a shocked variable (e.g. human capital) impacts another variable (e.g. EVA) keeping other shocks (e.g. capital expenditures, structural and relational capital and their lags) constant.

Using VAR for panel data, it is necessary to set a limit on the data structure: The random structure of cross-sectional data is generally assumed. This assumption is not consistent with the empirical data: Companies are heterogeneous; each has its own features. Thus, for a correct analysis, it is necessary to allow for individual heterogeneity within a cross-section, i.e., to use a statistic model with "fixed effects" (fixed effect model).

Since fixed effects are correlated with dependent variables (the problem arises because of the usage of lags), mean-differencing cannot be used. To avoid this problem of endogeneity, the Helmert procedure is used. This procedure removes the average value, calculated on future values, and keeps transformed and lagged regressors orthogonal. Thus, they can be used as instrument variables in evaluating the resulting system of equations using the method of moments. In this case, the model is not super-identified, so using the method of moments is equivalent to using the two-step OLS. To analyze IRF, it is necessary to assess confidence intervals. Since the IRF matrix is based on estimated pVAR coefficients, it is necessary to take standard errors into account. A Monte Carlo simulation is used in order to generate confidence intervals, since the distribution of standard errors is not parameterized: a bootstrap approach is used to approximate the distribution empirically.

# 3. Results

There is no empirical evidence that investments in intellectual capital contribute to the performance of pharmaceutical companies (Figure 1.). However some interesting findings can be derived. Firstly, an increase of capital expenditures leads to an increase of human capital or a reduction of structural capital. Consequently, structural capital and tangible assets could be subsituted one for another, to some extent. In this case, no positive return on investment in tangible assets is observed. Secondly, the relationship between capital investments and operating profit could be explained by the fact that capital investments respond to shocks in operating profit. Thus, in the pharmaceutical industry, an investment strategy whereby companies consistently invest a certain amount of operating profit into tangible assets can be noted. Also, investments in intellectual capital affect investments in tangible assets.

However, the graph shows a negative relation between economic profit and increase in human capital (Figure 2). Moreover, this response to current shock may become even stronger over the following several years. The negative relationship with capital investments could be explained by the fact that investments are rising, but there is no return on these investments during the analyzed period. Also capital expenditures distract from a company's economic profit or their contribution is close to zero. As far as they do not have a sustainable effect on operating profit, it can be resumed that pharmaceutical companies invest in tangibles without consideration of the cost of capital.

Thus, it can be assumed that, in the pharmaceutical industry, investments in tangible and intellectual assets (human and structural capital) have a return only within a period longer than four years. However, consideration of a model with longer time intervals requires consideration of more factors.

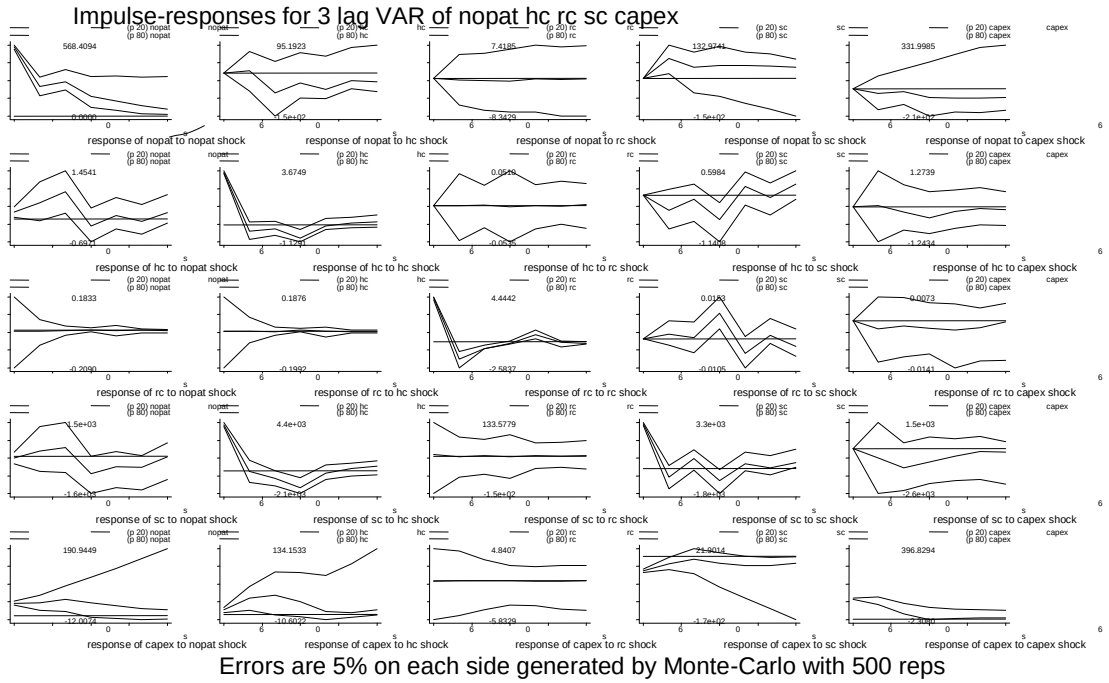


Fig. 1. Impulse responses for 2 lag VAR of NOPAT, human, relational, structural capital and tangible assets for pharmaceutical companies.

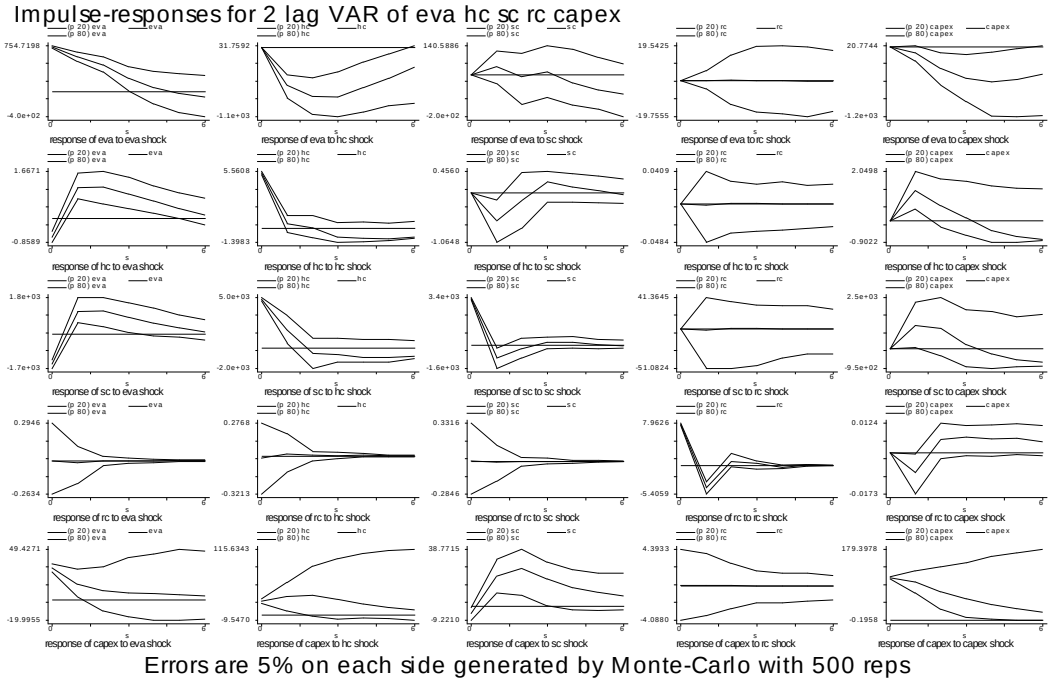


Fig. 2. Impulse responses for 2 lag VAR of EVA, human, relational, structural capital and tangible assets for pharmaceutical companies.

In the retail industry, no direct influence of intellectual capital on financial performance was observed (Figures 3 and 4). However, investments in structural capital frequently lead to a decrease in economic value added. Additionally human capital grows with an increase in operating profit (or economic profit). So, retail companies try to hire new employees when their

profits go up, but graphs show that this policy do not leads to a rise in profits. Also, as in the pharmaceutical industry, the capital expenditures is influenced by the shocks in structural and human capital and shocks in operating profit. Investments in structural capital and tangible assets are interrelated positively. In the retail industry they are probably complementary resources for a company.

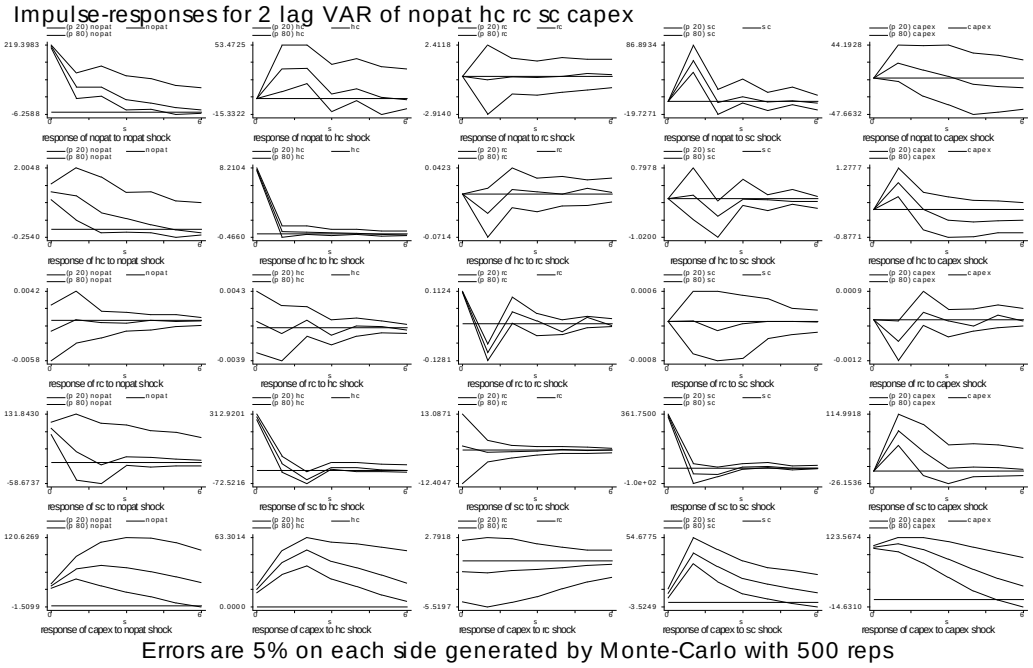


Fig. 3. Impulse responses for 2 lag VAR of NOPAT, human, relational, structural capital and tangible assets for retail companies.

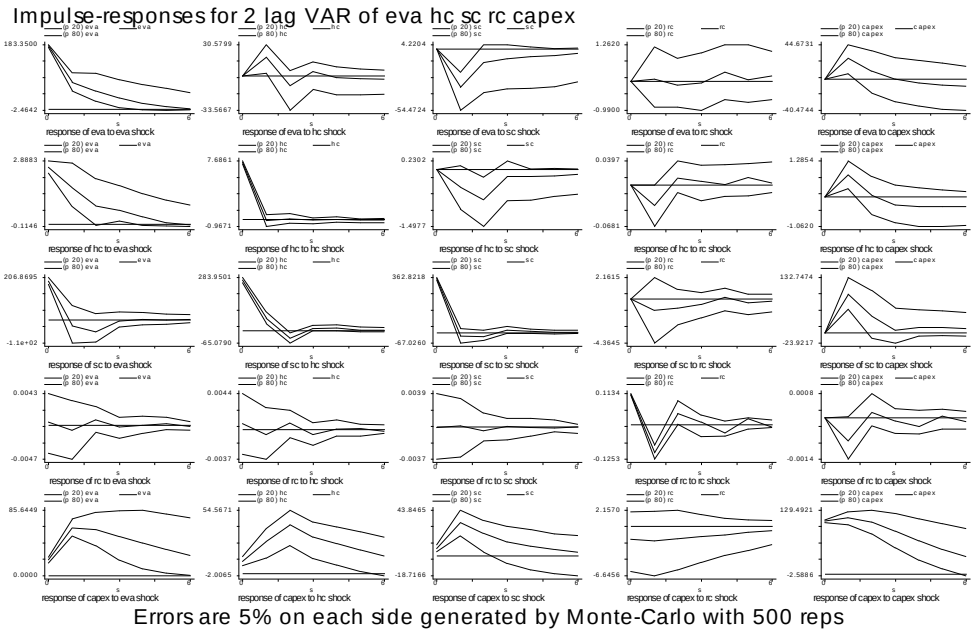


Fig. 4. Impulse responses for 2 lag VAR of EVA, human, relational, structural capital and tangible assets for retail companies.

For the telecommunications industry, a positive impact of investments in the human and structural components of intellectual capital and investments in tangible assets on economic value added is typical (Figure 6). At the same time the value of net operating profit has no linear relationship to intellectual capital (Figure 5). Also, it should be noted that there is a complex relationship between investments in intellectual capital and investments in tangible assets.

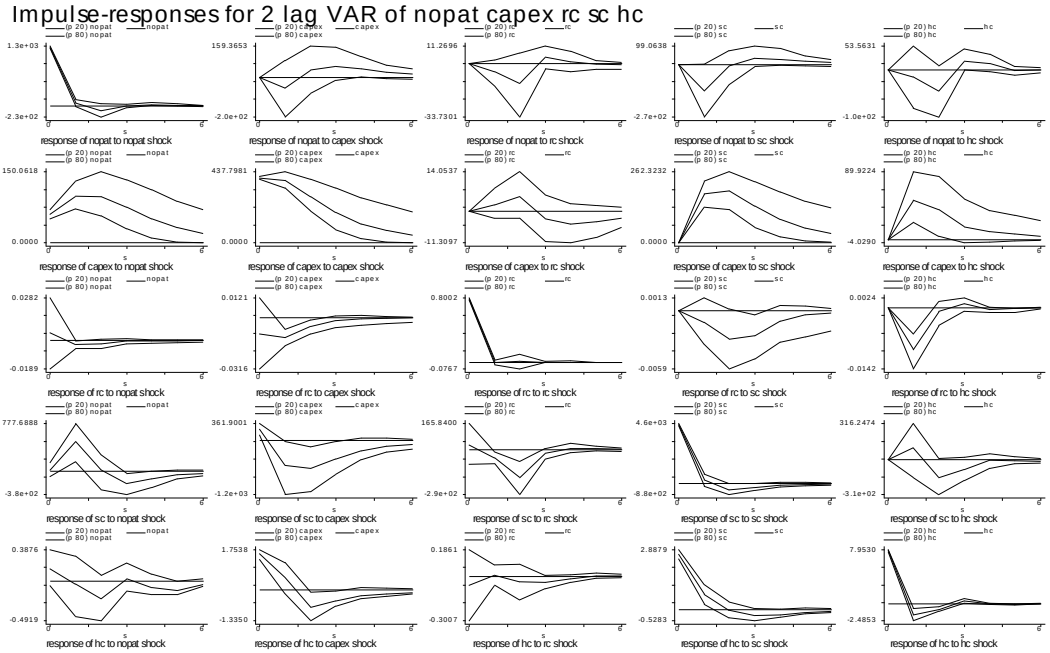


Fig. 5. Impulse responses for 2 lag VAR of NOPAT, human, relational, structural capital and tangible assets for telecommunications companies.

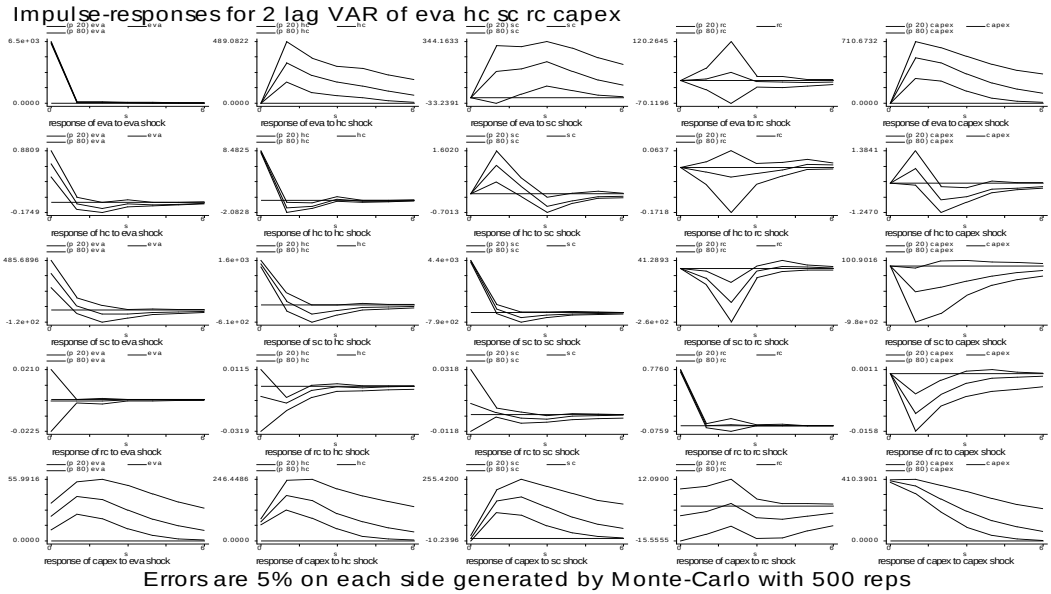


Fig. 6. Impulse responses for 2 lag VAR of EVA, human, relational, structural capital and tangible assets for telecommunications companies.

Consulting and educational services have no clear linear relationship between investments in tangible and intellectual assets and a company's financial results (Figure 7-8). In this case, making a profit does not increase investments. It can be assumed that the relationships between assets and a company's activity in the process of value creation are more complex than simple linear ones.

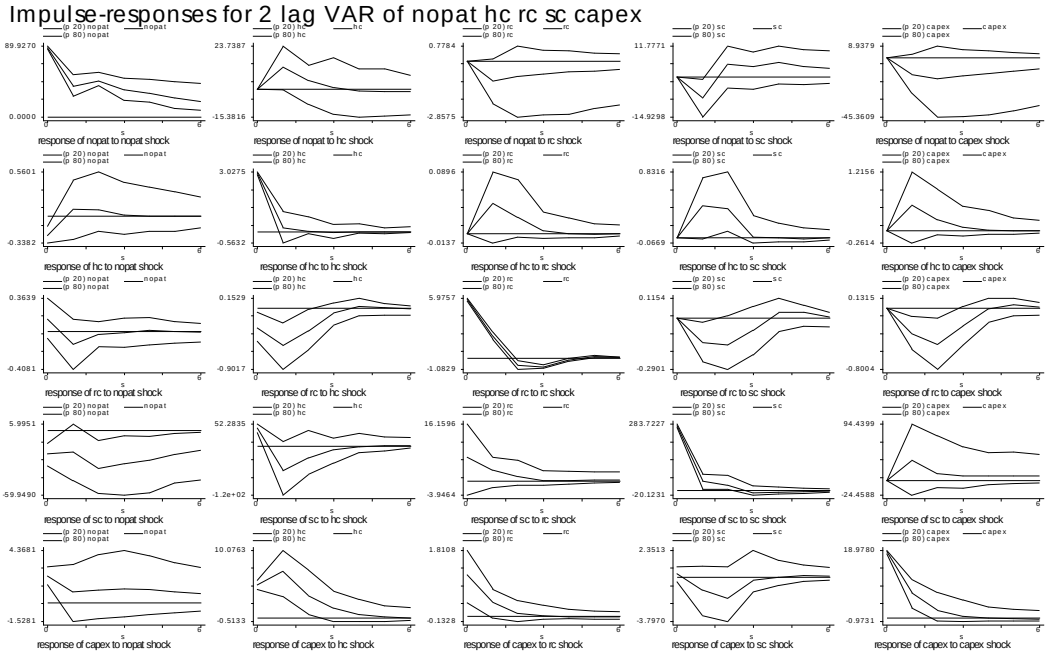


Fig. 7. Impulse responses for 2 lag VAR of NOPAT, human, relational, structural capital and tangible assets for service companies.

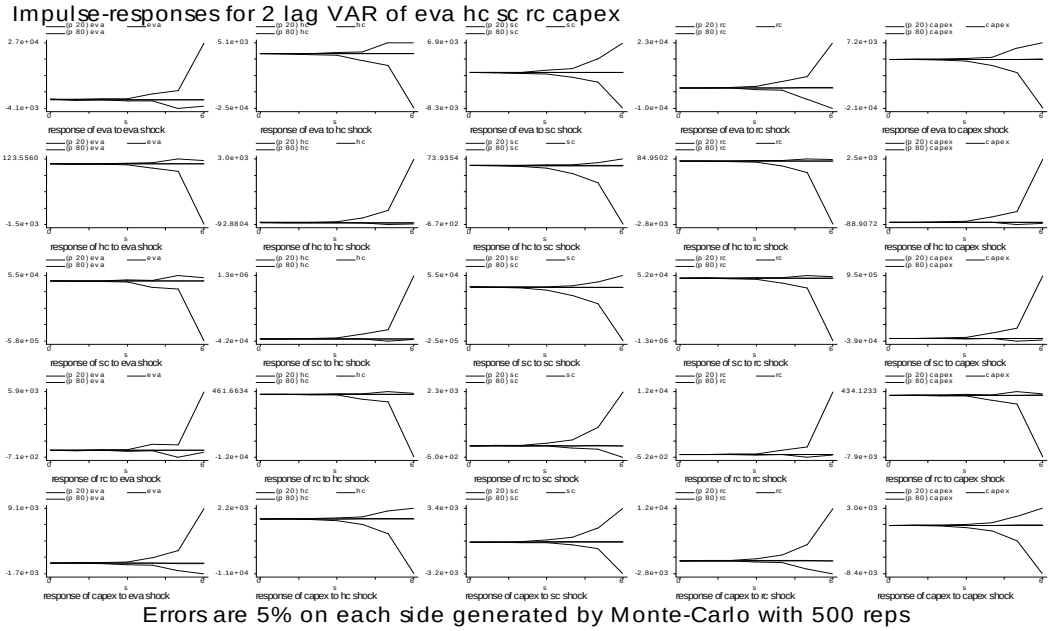


Fig. 8. Impulse responses for 2 lag VAR of EVA, human, relational, structural capital and tangible assets for service companies.

In the steel industry, the key factors of value increase are human capital and tangible assets (Figures 9-10). It should be noted that, in the steel industry, investments have a weak impact on reported financial performance. Also, in the steel industry, capital investments depend only on the value of capital investments in previous periods. This justifies the assumption that intellectual capital does not play a significant role in the steel industry, which is commonly regarded as being a traditional one.

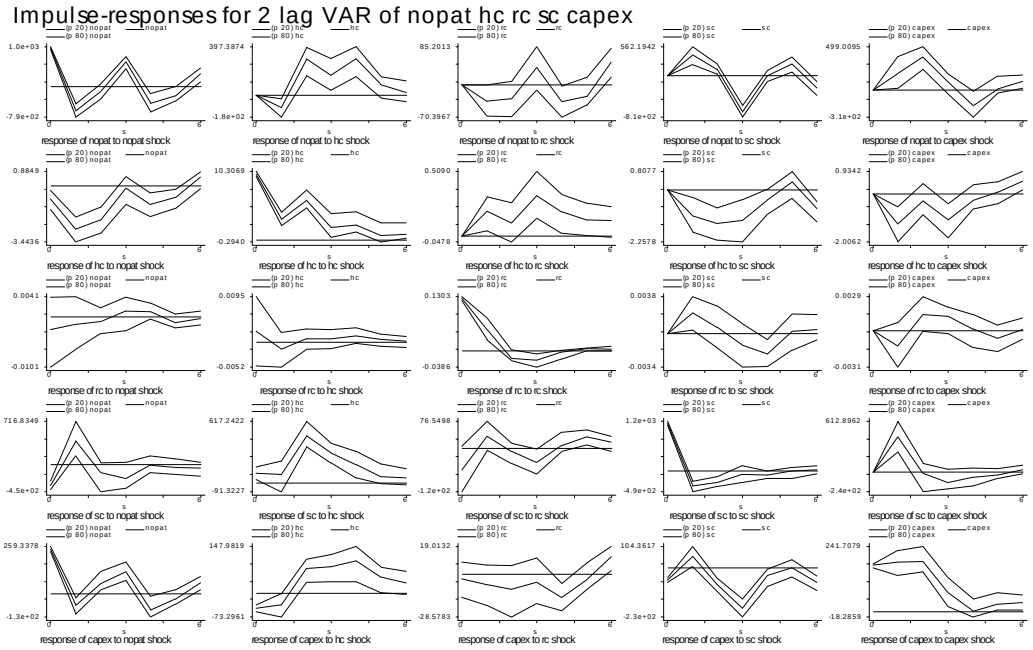


Fig. 9. Impulse responses for 2 lag VAR of NOPAT, human, relational, structural capital and tangible assets for steel companies.

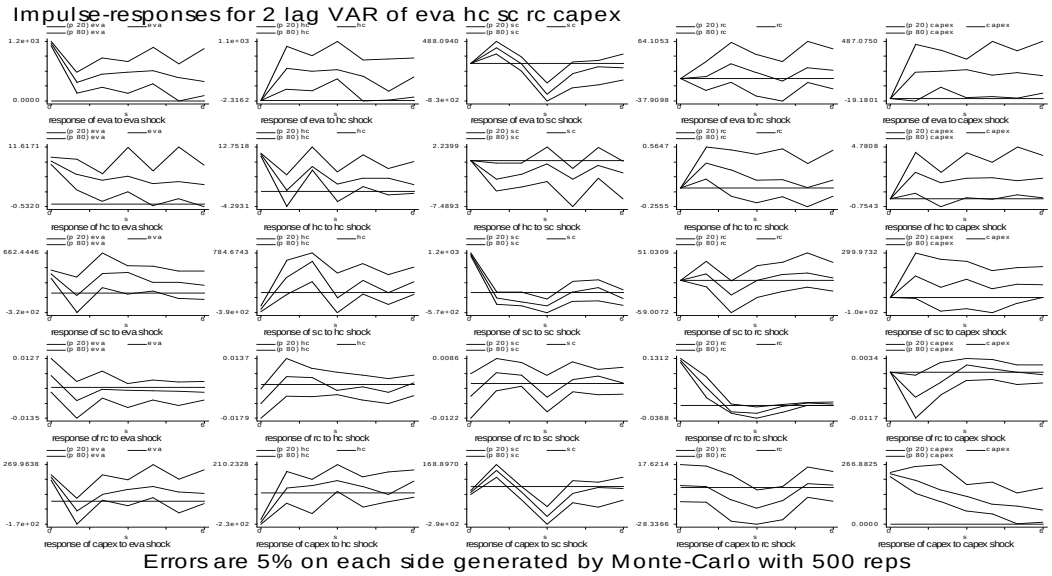


Fig. 10. Impulse responses for 2 lag VAR of EVA, human, relational, structural capital and tangible assets for steel companies.

# 4. Conclusion

In this paper, the authors analyzed the mutual influence of investments on different types of intellectual capital and company performance using panel VAR. The results suggest that there is a relationship between investments in intellectual assets and financial performance. There is also a reverse relationship. The significance of shocks in the impact of financial performance on investments in intellectual assets indicates the need to take this into account in future research on the contribution of intellectual capital to company performance.

Insofar as growth in intellectual capital is regarded as an investment, it should contribute to company performance for a long period of time (more than one year). The results evidence that such investments can give a positive return over the course of six years. However return on intellectual capital is frequently close to zero, or fluctuates with changing sign, or even is negative for a long period. Also, empirical research shows that management takes into consideration company performance when making investment decisions on capital expenditures, but not on intellectual capital. Moreover, there is a significant difference between the influence of investments on operating profit and on economic profit. Consequently the cost of capital should be taken into account. Contrary to the theoretical assumption that economic profit can not be earned from investments in tangible assets, research results show evidence that the influence of capital expenditures on EVA is significant. Furthermore the dependence between investments in intellectual capital components supports the idea that they could substitute or complement each other.

In addition, the authors identified a number of sectoral peculiarities regarding the relationship between intellectual capital and company performance.

- In industries with long production cycles, such as pharmaceuticals, investments in human and tangible resources could have a positive return after a long period of time, such as five years and more. For short-term investment returns, it is advisable to select companies with less current investments in tangible assets and human capital.
- In the retail industry, major investments in structural capital often do not lead to corresponding increases in operating profit, meaning that economic value added decreases.
- In the telecommunications industry, investments in human and structural capital and tangible assets contribute to the creation of economic value added. In this case, the most important roles are played by investments in human capital and

tangible resources of the previous year, and, as for structural capital, investments from the two previous years. Relational capital has no direct effect on company performance. Consequently, the efficiency of this type of capital is determined by the efficiency of other resources. Thus, telecommunication companies with large investments in human, structural, and tangible assets should be treated as preferred objects for investing.

- In the steel industry, investments in human capital and tangible resources play the most significant role, and their positive impact on value created remains during a long period of time with no significant weakening. Thus, choice of the investment object should be based on a maximum amount of investments accumulated over time.
- Value creation in companies providing consulting and educational services is a less definite process. To analyze the efficiency of investments in this industry, more detailed proxy-indicators of investments or an individual study of every company from this sector is necessary.

The results of this research support the idea that it is necessary to take into account the mutual dependence of IC components and performance – otherwise incorrect conclusions may be arrived at, due to the endogeneity problem. Another implication of this study is that it is essential to use dynamic models when modeling intellectual capital outputs. The authors consider the chosen methodology (orthogonal response functions) to be suitable for the analysis of such a complex process as the transformation of intellectual capital into value. Another important practical implication is that, surprisingly, IC does not significantly affect performance (or even have negative impact) in pharmaceutical, retail and service industries. This paper suggests a relatively easy way of estimating the time delay between IC investment and value creation. Taken together, this information can be used to develop a portfolio strategy based on IC of companies.

The findings in this research are subject to at least three limitations. Firstly, currently used proxies seem to be suitable, but it is interesting to collect more relevant data, especially for knowledge-intensive industries. Secondly, the authors consider only *linear* models, however, instinctively there are reasons to suppose nonlinearity in such a system. It is necessary to say that linear approximation is still correct, but a nonlinear model can have more descriptive power. Thirdly, for practical implications EVA can be easily replaced by market capitalization for portfolio-building purposes. However, in such a case much more control variables are required – market capitalization seems to be driven by many factors, not only IC investments.

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# Appendix

**Table 3. Descriptive statics of data used**

| Variable | Number of observations | Average | Standard deviation. | Min | Max |
|---|---|---|---|---|---|
| *Pharmaceutical industry* | | | | | |
| Investments in human capital (hc) | 927 | 0.33 | 3.53 | -20.66 | 63.35 |
| Investments in structural capital (sc) | 998 | 437.63 | 4 252.49 | -8 886.00 | 71 206.00 |
| Investments in relational capital (rc) | 868 | -0.20 | 15.52 | -276.59 | 307.00 |
| Investments in tangible assets (CAPEX) | 1160 | 205.50 | 569.53 | 0.00 | 3 106.19 |
| NOPAT | 1170 | 763.63 | 2 264.92 | -1 200.18 | 15 911.69 |
| EVA | 1162 | 625.09 | 1 977.94 | -4 264.83 | 12 693.93 |
| *Retail industry* | | | | | |
| Investments in human capital (hc) | 971 | 0.74 | 8.12 | -84.77 | 139.00 |
| Investments in structural capital (sc) | 963 | 9.80 | 424.14 | -5 783.00 | 6 656.37 |
| Investments in relational capital (rc) | 1005 | 0.01 | 0.21 | -2.74 | 4.17 |
| Investments in tangible assets (CAPEX) | 1128 | 210.47 | 505.32 | -0.08 | 4 010.00 |
| NOPAT | 1131 | 214.36 | 569.24 | -3 590.83 | 5 986.91 |
| EVA | 1121 | 150.00 | 480.40 | -3 419.14 | 5 550.54 |
| *Service industry* | | | | | |
| Investments in human capital (hc) | 1189 | 0.55 | 3.38 | -35.00 | 32.00 |
| Investments in structural capital (sc) | 1327 | 33.52 | 217.84 | -990.70 | 4 337.70 |
| Investments in relational capital (rc) | 1117 | 0.20 | 20.02 | -327.10 | 351.60 |
| Investments in tangible assets (CAPEX) | 1515 | 24.55 | 65.22 | 0.00 | 1 342.00 |
| NOPAT | 1515 | 67.84 | 218.21 | -1 384.12 | 2 524.13 |
| EVA | 1125 | 42.04 | 166.77 | -395.96 | 2 524.13 |
| *Steel industry* | | | | | |
| Investments in human capital (hc) | 351 | 1.10 | 10.50 | -37.88 | 149.19 |
| Investments in structural capital (sc) | 400 | 128.27 | 1 017.72 | -6 249.43 | 13 463.59 |
| Investments in relational capital (rc) | 404 | -0.01 | 3.87 | -64.71 | 31.43 |
| Investments in tangible assets (CAPEX) | 457 | 344.75 | 1 179.32 | 0.00 | 14 157.90 |
| NOPAT | 460 | 500.65 | 1 718.62 | -1 427.34 | 19 800.47 |
| EVA | 459 | 336.05 | 1 349.93 | -3 057.31 | 17 030.97 |
| *Telecommunications* | | | | | |
| Investments in human capital (hc) | 1519 | 0.55 | 9.78 | -99.49 | 196.91 |
| Investments in structural capital (sc) | 1625 | 305.99 | 4 538.37 | -37 429.86 | 104 839.00 |
| Investments in relational capital (rc) | 1664 | 0.25 | 8.25 | -40.05 | 317.76 |
| Investments in tangible assets (CAPEX) | 1896 | 1 074.78 | 2 616.27 | 0.00 | 20 478.00 |
| NOPAT | 1904 | 845.28 | 2 538.20 | -14 961.28 | 32 009.89 |
| EVA | 1892 | 318.85 | 2 224.89 | -27 376.30 | 31 227.48 |