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Exploring the motivation behind cybersecurity insider threat and proposed research agenda

[Research-in-Progress]

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Abstract

Cyber exploitation and malicious activities have become more sophisticated. Insider threat is one of the most significant cybersecurity threat vector, while posing a great concern to corporations and governments. An overview of the fundamental motivating forces and motivation theory are discussed. Such overview is provided to identify motivations that lead trusted employees to become insider threats in the context of cybersecurity. A research agenda with two sequential experimental research studies are outlined to address the challenge of insider threat mitigation by a prototype development. The first proposed study will classify data intake feeds, as recognized and weighted by cybersecurity experts, in an effort to establish predictive analytics of novel correlations of activities that may lead to cybersecurity incidents. It will also develop approach to identify how user activities can be compared against an established baseline, the user's network cybersecurity pulse, with visualization of simulated users' activities. Additionally, the second study will explain the process of assessing the usability of a developed visualization prototype that intends to present correlated suspicious activities requiring immediate action. Successfully developing the proposed prototype via feeds aggregation and an advanced visualization from the proposed research could assist in the mitigation of malicious insider threat.

Keywords: Insider threat, malicious insider detection, cybersecurity, motivation, cybersecurity simulation, data visualization in cybersecurity, proposed experimental research in cybersecurity

Introduction

The advent of the information age over the last 30 years has produced many technological innovations that assist society in communication, consumerism, innovation, and information gathering along with information decimation through the Internet. As the Internet continues to grow rapidly, illegal cybercrime has become a new channel for those seeking to break the law (Donner, Marcum, Jennings, Higgins, & Banfield, 2014; Wang, 2007). According to Gray and Hovav (2014), "we live in Internet time where change appears endemic and things happen much more quickly than other fields" (p. 337). Cyber exploitation and malicious activities have become more targeted and sophisticated (Choo, 2011). Advances in technology have increased the need for expert analysis, since the nature of cybercrime is rooted in information systems (IS) (Gottschalk, Filstad, Glomseth, & Solli-Saether, 2011).

Donner et al. (2014) defined cybercrime as "any form of online deviance utilizing technology" (p. 166). Cybercrime can be challenging to prove since procuring digital evidence may be extremely difficult to trace (Donner et al., 2014; Wang, 2007). Linking patterns in behavior is a major task when investigating motivation (Dweck & Leggett, 1988; Pfleeger & Caputo, 2012). Malicious insiders have found methods to abuse, manipulate, and often profit from technology, regardless of the damages such actions may cause (Claycomb, Legg, & Gollmann, 2013). It is the intent of this paper to provide the theoretical foundation for understanding the motivation factors that may lead trusted employees on a path to malicious behavior. This will set the premise for better understanding the data scheme needed for detecting malicious insider threat. Further, this work will extend into providing an outline for two distinct work-in-progress experiments that will approach the challenge faced when detecting malicious activities.

The insider threat is recognized as one of the most significant problems, while poses a great concern to both corporations and governments alike (Agrafiotis, Legg, Goldsmith, & Creese, 2014). Insider threats are minimally addressed by current information security practices, yet these insiders pose the greatest threats to organizations through various malicious activities (Punithavathani, Sujatha, & Jain, 2015). Many insider attacks emerge from the misuse of access privileges granted by organizations to their trusted internal employees, contractors, or third-party service providers (Ballesteros, Batten, Pan, & Li, 2015). The malicious acts that are carried out by these trusted insiders include, but are not limited to the theft of intellectual property, disclosure of national security information, fraud, and sabotage (Lindauer, Glasser, Rosen, & Wallnau, 2013).

Given such difficulty and gap in the research, the research problem that this work will aim to address is the challenge faced when mitigating malicious cybersecurity insider threat (Nostro, Ceccarelli, Bondavalli, & Brancati, 2014). This challenge is significant since insiders have more information than an external hacker (Hunker & Probst, 2008). Malicious activity or criminality refers to stable differences across entities in their inclination to commit malicious or criminal acts (Birkbeck & LaFree, 1993). According to Hirschi and Gottfredson (1987), criminality alone does not suffice for criminal activity; for a malicious or criminal act to occur, situational encouragement in the way of motivation and opportunity must exist. Coleman (1992) argued that personal monetary gains play a major role in motivating misbehavior in some cultures. Birkbeck and LaFree (1993) provided a connection between motivation, opportunity, and crime, concluding that motivation in the context of crime involves willingness to commit such crime and is contingent upon opportunity. Osgood, Wilson, O'Malley, Bachman, and Johnston (1996) later applied the conclusions of Birkbeck and LaFree (1993), by finding that unstructured socializing activities resulted in more deviant behaviors. Though money, time, as well as other factors may be a driving force behind malicious activity, understanding the motivating factors that influence trusted individuals to perform malicious acts and presenting patterns in a clearly decipherable interface will aid in mitigating malicious insider threat.

The overall impact of a malicious attack depends on the motivation behind the attack (Hunker & Probst, 2008). Osgood et al. (1996) illustrated several researchers that have investigated the relationship between deviant behavior and the way that people spend their time. They indicated how crime is dependent on opportunity, in accordance with Briar and Piliavin (1965)'s idea of situational motivation, which stated that the motivation for delinquency is implanted in the situation rather than the person (Osgood at al., 1996). According to Coleman (1987), in 1939, Southerland defined the concept of white-collar crime as "a crime committed by a person of respectability and high social status in the course of occupation" (p. 407). Applying this concept to the technologies and integrated computational devices available today, a new paradigm emerges as a people and organizational issue; that of insider misuse of IS in the form of delinquent behavior in the workplace (Theoharidou, Kokolakis, Karyda, & Kiountouzis, 2005). Therefore, the central aim of this work-in-progress is to outline a research agenda for two proposed complementary experimental research studies that will curve the path for the development of a prototype for detection and alerting of insider threat in organizational settings. The next section will provide some preliminary theoretical foundation by discussing motivational factors and theory, followed by the proposed research agenda, and finally, concluding with discussions of the intendant contribution of the proposed research agenda.

Theoretical Framework

The theoretical foundation applied to this stream of research is the theory of motivation. Motivation is a classical construct and refers to the key influencers on behavior though other options are present (Tolman, 1938). When faced with a problematic situation, given consideration of possible outcomes and consequences, motivation drives the particular behavior that is selected and performed through alternate means are available (Foote, 1951). Current literature acknowledges three streams of research as the foundation for the study of motivation. Kanfer (1990) identified the three streams of motivation theory research as:

1. Need-motive-value research, or person based determinants of behavior;
2. Cognitive choice research, or expectancy-value formulations;
3. Self-regulation-metacognition research, which focus on target cognition-behavior relations such as goal setting, and cybernetic control theories.

In order to understand motivation within the context of IS security theory development, all three research streams, their constructs, and theories should be analyzed. As presented by Atkinson and Birch (1970), motivation is not directly observable – what is observed is an intricate course of behaviors and the results of such behaviors. Dweck and Leggett (1988) concluded that motivational processes that affect behavior were the result of personality variables. Kanfer (1990) indicated that motivational processes can only be inferred by the analysis of the streams of behavior, that are derived from congenital traits and environmental factors, which are "observed through their effects on personality, beliefs, knowledge, abilities, and skills" (p. 78). Consequently, Wang and Lin (2007) observed motivational factors on collaborative learning finding that collective efficacy had a positive effect on discussion behavior.

Turner (1987), in his seminal work, presented the exchange theoretic model of motivation, which highlighted the importance of marginal utility/satisfaction and profit/loss. The augmentation of satisfaction is supported by research that suggests that self-efficacy, an individual's beliefs in their ability to achieve designated goals or performance, is the greatest motivational factor in an individual's choice of activities, effort, persistence, and performance (Wang & Lin, 2007). The fundamental motivating force in classical utilitarian theory is the desire to augment satisfaction, and to circumvent deprival or retribution in social transactions (Turner, 1987). In contrast, Kanfer (1990) indicated that the dependent variables most common in motivation research are direction of behavior, intensity/action/effort, and the persistence of specific behaviors over time. In workplace setting, motivation can be ascribed to what an individual does (direction), an individual's work ethic (intensity), and the duration of an individual's work time frame (persistence) (Kanfer 1990). Thus, motivation can be ascribed from many aspects of the individual, which may be complex to fully understand.

Proposed Experimental Research and Procedures

In his classical work, Sutherland (1940) integrated sociology and business to better understand white-collar crime. To understand organizational deviance Vaughan (1999) applied sociological theory to assess that organizational deviance is routine nonconformity. Like cybercrime, white-collar crime may be inconspicuous and very difficult to substantiate (Gottschalk, Filstad, Glomseth, & Saether, 2011). Similarly, future research will aim to apply sociological theories like the theory of motivation when assessing insider threat mitigation. Theoharidou et al. (2005) applied sociological perspectives to understand the approach followed by ISO177799 (Code of Practice for Information Security Management) when dealing with insider threat, since the social environment plays a critical role in the formation of motivation. Pfleeger and Caputo (2012) argued that incorporating an understanding of human behavior into cybersecurity technologies would aid in better development, design, and use of such tools. To better facilitate design and development of insider threat mitigation technologies, this literary analysis interprets the motivational factors that lead individuals toward malicious behavior.

A significant impediment to insider threat research programs is the lack of data to analyze (Lindauer, Glasser, Rosen, & Wallnau, 2013). In order for the data to be useful it must contain a comprehensive account of human behavior from within the monitored environment (Glasser & Lindauer, 2013). According to Lindauer et al. (2013), researchers in the insider threat domain have two options, either collect real data or use synthetic data. With mature synthetic data, a researcher can flexibly control and economically generate data sets with the desired characteristics, size, quality, and necessary measurable properties (Lindauer et al. (2013). As noted by Glasser and Lindauer (2013), because they are not real, the data sets are complete, and free from privacy restrictions or limitations. U.S. law emphasizes that the workplace and its resources are the property of the employer, furthermore, the employer is generally free to dictate permissible use of company property as the employer sees fit (Abril, Levin, & Del Riego, 2012). According to Grizalis, Strarou, Kandias, and Stregiopoulos (2014), when dealing with employee monitoring, the organization should establish a legal, affordable, and effective monitoring solution that is acceptable to all stakeholders, although have the full right to monitor employees activities both physically and digitally for the purpose of organizational protection. Any data collected as a result of monitoring should be secured and should be solely for the purposes of protecting and optimizing resources (Grizalis et al., 2014).

For the purposes of this experimental study, synthetic data will be used. The proposed Analytics-based Identifying Insider Cybersecurity Threat in Real-time (AI-InCyThR™) will perform similar to network based Security Information and Event Management (SIEM) solutions, establishing an assumed baseline representing the cybersecurity pulse. The user's network cybersecurity pulse will serve as an established baseline from which the AI-InCyThR™ will test and compare against. The AI-InCyThR™ will analyze the synthetic data, system logs, and behavioral data feeds. Through the use of data mining and predictive analytics, the collected data will be refined and any Type I (false positives) along with Type II (false negatives) errors, as well as correlations will be identified. Once the data has been scrubbed, the recognized feeds, weights, as well as linear and non-linear correlations will be measured against the National Institute of Standards and Technology (NIST) Cybersecurity Framework. This procedure will create a set of evidence and/or correlations as precursors to malicious cybersecurity insider threat events.

First Proposed Experimental Research

Punithavathani et al. (2015) found "the fact that the term "Insider" is in and of itself elusive that makes this issue and its many dimensions truly more difficult to understand" (p. 435). The first proposed experimental research will be conducted as a developmental study in three phases. As indicated by Ellis and Levy (2009) "developmental research attempts to answer the question: How can researchers build a 'thing' to address the problem?" (p. 326). The first proposed experimental study will develop and validate a prototype for an analytics-based malicious cybersecurity insider threat in real-time identification system.

Phase one developed proposed benchmarking instruments, known as feeds, for thorough understanding of the insider threat phenomenon a depth of exploration and analysis of the existing literature was performed. From the literature, trends and recurring themes were identified for the formulation of human-centric and techno-social feeds. Human-centric feeds are feeds that relate to individual behavioral indicators either produced by the individual employee or recorded by human resource professional, colleague, or supervisor. These include but are not limited to: stress, disengagement, anger management, personal issues, and financial difficulties.

On the other hand, techno-social feeds, are feeds produced by actor activities, which register the employee's behavior and habits on the organizational network.

When comprehensive lists of feeds have been identified, a panel of IS security experts from both industry and academia will be solicited to participate in two Delphi method evaluations of the recognized feeds validation. Once the experts have classified the most important feeds needed to identify insider threats, the experts will perform a second evaluation using the Delphi method to assign the feeds weight allocations in order of importance and unit of measure. Feeds will be collected from several sources to include, operating system registry entries, firewall traffic, e-mail, network enabled mobile device activity, Web content filtering, network bandwidth usage, and other readily available system logs.

Phase two of this study will include the development of the AI-InCyThR™ System. The AI-InCyThR™ system will apply determined feeds against a data set of simulated user activity available from Carnegie Mellon University's (CMU) Computer Emergency Response Team (CERT), which was obtained. The data sets provide both simulated background data, and data from simulated malicious actors. It is these simulated data sets that this study will utilize as the foundation for the prototype development. The data sets and fields are illustrated in Table 1.

Table 1: Simulated user activity data set

Data Set	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8	Field 9	Field 11	Field 12	Field 13
Logon	ID	Date	User	PC	Activity (Logon/Off)							
Device	ID	Date	User	PC	File tree	Activity (Connect/ Disconnect)						
HTTP	ID	Date	User	PC	URL	Activity	Content					
Email	ID	Date	User	PC	To	CC	BCC	From	Activity	Size	Attach	Content
File	ID	Date	User	PC	File name	Activity	To USB	From USB	Content			
LDAP	Employee Name	User ID	Email	Role	Business Unit	Functional Unit	Dept	Team	Manager			
Psycho Metric Big 5 Score	Employee Name	User ID	O	C	E	A	N					

Similar to network based SIEM solutions, the proposed AI-InCyThR™ prototype system will perform passive listening for a short timeframe establish the user's network cybersecurity pulse. The user's network cybersecurity pulse will serve as an established baseline from which the AI-InCyThR™ will test and compare against. The AI-InCyThR™ will collect simulated data, system logs, and behavioral data for analysis. Through the use of Splunk, Hadoop, and Big Data analytics tools, the collected data will be refined and Type I (false positives) along with Type II (false negatives) errors, as well as correlations will be identified. Once the data have been scrubbed the recognized feeds, weights, and correlations will be measured against the National Institute of Standards and Technology (NIST) Special Publication (SP) 800-37 Risk

Management Framework (RMF). This procedure will create a set of evidence and/or correlations (linear & non-linear) as precursors to malicious events. Phase three of the first proposed experimental research will begin the analysis of the evidence and/or correlations against the cybersecurity pulse, and the development of the correlation hierarchical bundling visualizations will occur; with correlations established through real-time data visualization and chord diagrams as seen in Figure 1.

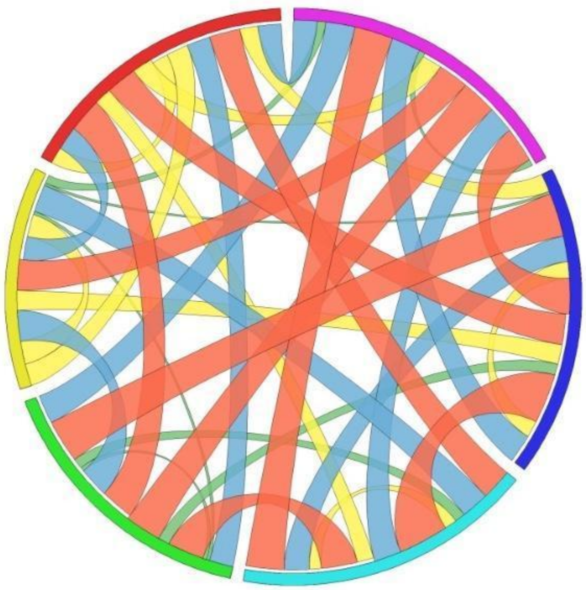

Figure 1: Proposed Correlation Hierarchical Bundling Visualization for AI-InCyThR™

The study continues with an analysis of the findings for overall detection accuracy of predicted malicious events with and without correlations visualizations, as well as the composition of a comparative report, conclusions, and recommendations.

Second Proposed Experimental Research

As insiders become more elusive there is also an increased number of false alerts desensitizing analysts that may result in them ignoring all alerts (He, Zhang, Ma, & Guan, 2015). Thus, the consecutive extension of this work will propose a second experimental research that will develop visualization module for the AI-InCyThR™ prototype that will simplify and decrease efforts of cybersecurity analysts attempting to react to trivial alerts. Therefore, the second study will approach this challenge from a perspective that has been minimally assessed to enrich the analytic process through a novel simplified visualization. Attempting to effectively explore data containing complex or multidimensional data sophisticated visualization techniques are needed, using information visualization technologies will aid in improved data analysis especially in areas like fraud or malicious detection (Keim, 2002). Examples of simplified visualizations exist in other industries where false alerts minimization is critical, such as within healthcare and aviation. Within healthcare, visualizations are often used to provide practitioners critical information such as vital signs during emergency medical situations to make lifesaving decisions (Harries, Zacharaih, Kapur, Jahn, & Enarson, 2009). Within aviation, Pilots use a Heads Up Display (HUD) continually references external visual cues and make decisions in the event of abnormal changes (Dopping-Hepenstal, 1981). A simplified executive insider-threat pulse dashboard visualization within the domain of cybersecurity may be utilized to expedite the comprehension of cybersecurity alerts allowing for quick decisions during critical attacks.

Riveiro (2014) argued that there is a lack of appropriate cognitive support for operators to comprehend system outcomes. The proposed second designed experimental research study will assess the ability to identify anomalous and potentially malicious activities utilizing a newly developed added module for the AI-InCyThR™ prototype, called Quality User Insider ChecKing visualization (QUICK.v™) module. Using human-computer interaction (HCI) methods and visualization techniques an added module prototype will be developed then tested utilizing information security professionals. This prototype intends to obtain data from SIEM applications and big data analytics tools to drive the information necessary to generating the cybersecurity vital signs on the proposed front-end executive dashboard. Pfleeger, Predd, Hunker, and Bulford (2010) identified four points that would assist with understanding risky insider actions: the organization, the individual, the information technology (IT) system, and the environment (p. 173). These points are utilized for framing the four vital signs depicted within Figure 2. The vital lines will be developed based on a trend chart depicting events per second within each area over a defined period of time. The developed prototype will include customizable fields indicating potentially high-risk activities that may require investigation. This will aid in resolving the problem faced today where potentially useful data continues to be collected and stored, and resources become paralyzed by the overwhelming quantity of what becomes meaningless data, unless this can be better visualized (Keim, 2002).

The research methodology for the second proposed experimental study within this proposed stream of research will develop and validate an executive insider-threat pulse dashboard prototype using a visualization (noted as QUICK.v™) that will aid in identifying anomalous activities of suspicious cybersecurity insiders. Within the initial phase of the second proposed experimental research, a preliminary add module for the prototype will be developed for analysis of the visualizations of complex data correlations. Identical data will be presented using varying types of visualizations identified as plausible within HCI research. The next phase of second proposed experimental study will assess the effectiveness of the developed executive insider-threat pulse dashboard visualization prototype using a group of 30 subject matter experts (SMEs). Recommendations of the SMEs will then be integrated to refine the prototype. The final phase of second proposed experimental study will assess the types of correlations (linear & non-linear) that allow for effective detection of anomalous insider-threat activities under the simulated environment. After the experiments are completed, revisions to the prototype will be made and recommendations for improvements will be provided.

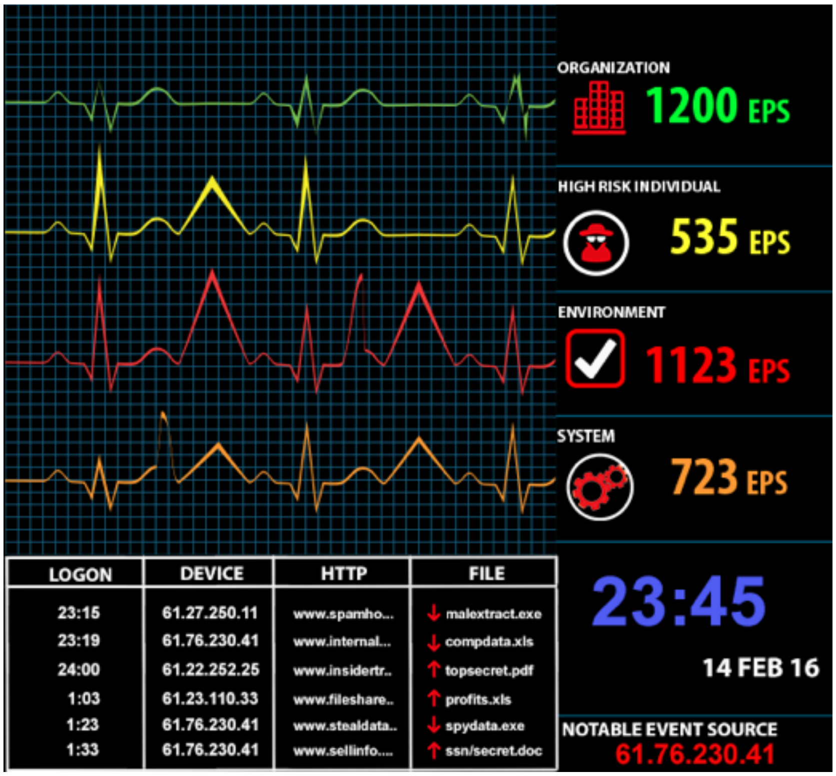

Figure 2: Proposed Quality User Insider ChecKing visualization (QUICK.v™) interface

Conclusion

This research agenda outlines two proposed experimental research studies in progress aimed at mitigating malicious cybersecurity insider threat. The first experiment will encompass three phases, the first phase comprises of identifying valid benchmarking feeds list. The second phase includes the development of the Analytics-based Identifying Insider Cybersecurity Threat in Real-time (AI-InCyThR™) System, and within the third phase correlation analysis and correlation hierarchical bundling visualization will be produced. The second experimental study will entail developing the Quality User Insider ChecKing visualization (QUICK.v™) module for simplified identification of anomalous and potentially malicious activities. The development of these prototypes and the results of the experiments should provide some initial steps to address the challenge of mitigating malicious cybersecurity insider threat beyond the existing SIEM tools currently available. This stream of research is expected to provide additional insights for understanding the motivation that drives malicious behavior, therefore, aiding in establishing tools for prompt detection of suspicious activities. Overall, both studies will attempt to holistically address the issue of malicious cybersecurity insider threat. By enhancing the backend to intrinsically utilize more of the big data already being collected, this proposed line of research is aimed to increase precision when identifying suspicious activities that leads to malicious cyber threats. Then applying a front end with enhanced usability and simplified visualization metrics. Identifying and counteracting malicious cybersecurity insiders can be streamlined. Theses proposed work-in-progress research studies would assist cybersecurity practitioners to significantly mitigate malicious cybersecurity insider threat once completed.

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Knowledge creation, turbulence, and manufacturing flexibility roles in business performance and operations performance

[Research-in-Progress]

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Abstract

This study examines the impact of knowledge creation, technological turbulence, and manufacturing flexibility on business performance and operations performance (time, cost, & quality) in manufacturing firms. The contribution is to establish manufacturing flexibility as a mediator of the relationships of knowledge creation and technological turbulence with business and operations performance. Using a sample of 370 manufacturing firms, the study finds that knowledge creation positively affects business performance and operations performance directly and indirectly through manufacturing flexibility. Furthermore, the relationships between technological turbulence along with business and operations performance are mediated by manufacturing flexibility. The study also reveals that the relationship between manufacturing flexibility and operations performance is contingent on the level of market turbulence. The effect of manufacturing flexibility on operations performance is stronger under high market turbulence than under low market turbulence. Results suggest that: (a) firms can reinforce manufacturing flexibility in order to perform better under higher market turbulence conditions; and (b) firms can improve manufacturing flexibility by fostering knowledge creation and using technological turbulence as an incentive.

Keywords: Knowledge creation, manufacturing flexibility, business performance, operations performance, technological turbulence, market turbulence

Introduction

Grant (1996) developed a knowledge-based theory used to analyze the processes of knowledge integration required to create the dynamic and flexible response capabilities critical for organizations adapting to hypercompetitive markets. Manufacturing flexibility is one of the most important capabilities a manufacturing firm must have for coping with environmental turbulence (Swamidass & Newell, 1987). Dreyer and Gronhaug (2004) concluded that multi-dimensional flexibility including supply, production, and product assortment flexibility is necessary for firms facing highly volatile and unpredictable environments. While manufacturing flexibility is critical, it is paradoxically identified in the literature as having intrinsic characteristics that cause tension due to the friction between change and preservation within the firm (Volberda, 1996). Manufacturing flexibility is one of the requirements for change processes in manufacturing firms that leads to higher levels of performance. Anand and Ward (2004) argued that flexibility is a strong antecedent of performance, especially in turbulent environments. Lloréns, Molina, and Verdú (2005) stated that manufacturing flexibility can be a crucial factor for strategic change to environmental factors and internal resources that impact the firm's performance. Kara and Kayis (2004) argued that manufacturing flexibility can be achieved through a firm's investment to commit time and resources. The asymmetric time impact of costs and benefits is a common characteristic of dynamic capabilities. In an analysis of the relationship between resources, dynamic capabilities, and performance, Wu (2006) found that resources affect performance rather indirectly through dynamic capabilities, namely innovation and market response speed, as well as through manufacturing efficiency and flexibility (thus identifying manufacturing flexibility as a dynamic capability). Links between the assimilation of knowledge-capabilities and the impact on developing manufacturing capabilities have been established by Tu, Vonderembse, Ragu-Nathan, and Sharkey (2006) found a link between the assimilation of knowledge-capabilities and the impact on developing manufacturing capabilities indicating that firms adapting to their competitive environment should foster knowledge assimilation, sharing, and creation, in order to better assimilate innovative manufacturing technology. Urtasun-Alonso, Larraza-Kintana, García-Olaverri, and Huerta-Arribas (2014) concluded that firms with higher levels of manufacturing flexibility display higher advanced human resources management practices as well. These studies suggest that manufacturing flexibility lies at the core of a relationship between knowledge-capabilities and forms of firm performance. Using a knowledge-based perspective, this study examined the impact on business performance and operations performance (time, cost, & quality) of manufacturing flexibility along with its role in the practical integration of knowledge creation and technological turbulence. The study also examines the mediating role that manufacturing flexibility plays in such relationships and the way it changes for groups of firms perceiving different market turbulence levels. The main contribution of this study is the confirmation of the mediation of manufacturing flexibility in the relationship between knowledge-capabilities (specifically, knowledge creation) and performance. This perspective in manufacturing flexibility illustrates a value creation capability, converting knowledge creation into business performance and operations performance.

Research Hypotheses

Technological change is a measure of the rate of change and impact of technology (Jaworski & Kohli, 1993). Technological turbulence, the volatility observed in technological change, poses both threats and opportunities for manufacturing firms as an incentive to change that can be mis-applied by firms or alternatively, engaged with to benefit a firm's strategy. Kessler and Chakrabarti (1996) argued that technological turbulence provides an incentive for the need of innovation speed as new technologies enable new products and services. The constant development of new technologies can directly impact manufacturing flexibility, as it provides the opportunity to set technological roadmaps for manufacturing processes related to the development of manufacturing flexibility. Ahlström and Westbrook (1999) observed that advances in the manufacturing function can be crucial to achieve mass customization involving manufacturing flexibility and implicitly, knowledge of technology advances. The more technology changes, the more the components, processes, techniques, and methods required for producing organizational outputs tend to change. The more intense the impacts of technological change, the greater the necessity for the firm's capability to change, adapt, even entirely replace existing configurations (Lavie, 2006). There is a strong learning component in the adaptation of manufacturing firms to technological changes and in the integration of new technologies in manufacturing processes. The outcomes of Spanos and Voudouris (2009) support a gradual technology accumulation process that progresses from the less complicated to more articulated technologies. Among the most crucial antecedents of advanced manufacturing technology identified are absorptive capacity and environmental pressures. This study hypothesizes that: *H1a: Technological turbulence is positively associated with manufacturing flexibility*.

Anticipating obsolescence requires knowledge-capabilities since without it technological changes and its implications cannot be fully understood, thus, limiting the development of adequate levels of manufacturing flexibility. Coping with technological change requires knowledge-capabilities, which in turn can also be regarded as dynamic capabilities. An example of this is the Camuffo and Volpato (1996) case study focused on the connection between dynamic capabilities and Fiat's operations. They found that the implementation and development of automation techniques were a path-dependent, non-linear, learning process. They argued that the technologies used by Fiat resulted from learning, internal developments, external acquisitions, imitation of competitors, along with the replication and selection of capabilities. Within knowledge-capabilities, the creation of knowledge can be regarded as an end step requiring an antecedent sequence of other knowledge-capabilities, such as knowledge acquisition, assimilation, transformation, exploitation, along with the combination of existing and acquired knowledge. Nonaka (1994) stated that organizational knowledge is created through the exchanges happening between tacit and explicit forms of knowledge in organizations and the conversion of both into new forms of knowledge. This requires the action of time and a conscientious combination of resources with both being trace features of dynamic capabilities at play. Koh and Gunasekaran (2006) suggested that manufacturing firms should use tacit and explicit knowledge for managing uncertainty in order to better integrate materials requirements planning, manufacturing resource planning or enterprise resource planning systems. Thus, they argued the crucial role of knowledge management in the integration of key manufacturing support processes and its complementarity adoption of advanced technology. This study hypothesizes that: *H2a: Knowledge creation is positively associated with manufacturing flexibility.*

Evidence exists to explain why advanced manufacturing systems requiring high technology know-how positively affect operational and business performance. Raymond and St. Pierre (2005), focusing on Canadian manufacturing SMEs, have found that advanced manufacturing systems affect operational performance as well as business performance. They have also identified education and experience of the owner-manager, strategic orientation, and type of production and dependency of small manufacturers as antecedents of advanced manufacturing systems. Sharkie (2003) defended that firms operate through people and that it is their contribution that leverages the emergence of competitive advantage. He stated that management needs to nurture a knowledge creation environment within the firm so resources can be exploited and developed in full to compete with rivals. Carlucci, Marr, and Schiuma (2004) explored the mechanisms through which knowledge management can have impact over business performance, designating such paths as the knowledge value chain. They discussed the strategic, managerial, and operations dimensions of knowledge management, effectively linking knowledge management not only with competencies and processes, but also with business performance and value creation. Chaturvedi, Chatawai, and Wield (2007) studied the transformation processes inherent to Indian pharmaceutical firms, which have moved from reverse-engineering and a domestic market focus, to research-driven and a global market focus. They argued that more successful companies are those that have managed to evolve through knowledge-based strategies, which in fact directly links knowledge-capabilities with competitive advantage and business performance. In view of the aforementioned literature, this study hypothesizes that: *H2b: Knowledge creation is positively associated with business performance.*

In this study, it is hypothesized that knowledge creation may be positively and directly related to manufacturing operations performance (time, cost, & quality), which goes beyond the more consensual hypothesis of the link between knowledge creation and business performance. If it is possible to regard knowledge creation as a superior order capability amongst knowledge-capabilities, it becomes possible that not only will knowledge creation positively affect manufacturing flexibility, but will also generate, in time, the skills to appropriately and more efficiently manage any operational process gradually perfecting its levels of operational performance leading to better lead times, lower costs, and higher quality levels than rivals. Lloréns, Molina, and Verdú (2005) examined the determinants of manufacturing flexibility affecting desired strategic change and performance finding that environmental factors as well as internal resources affect flexibility with the former aspect affecting performance. Thus, the hypothesis is: *H2c: Knowledge creation is positively associated with operations performance (time, cost, & quality).*

If manufacturing flexibility is required for firms to better address their changing market and technological environments, then it should be possible to observe the relationship between higher levels of manufacturing flexibility and firm performance. Anand and Ward (2004) provided empirical evidence in favor of the view of manufacturing flexibility as an antecedent of performance, especially for firms acting under higher turbulence environments. Wu (2006) also provided empirical evidence that resources affect performance predominantly in an indirect way through dynamic capabilities including operational capabilities such as manufacturing efficiency and flexibility. Furthermore, the impact of manufacturing flexibility on performance may be revealed in business performance as well as in operational performance indicators. This study hypothesizes that: *H3a: Manufacturing flexibility is positively associated with business performance.*

Swafford, Ghosh, and Murthy (2008) established supply chain process flexibilities as antecedents of supply chain agility, specifically concluding that a firm's supply chain agility is positively affected by the degree of flexibility in the processes of manufacturing, procurement and distribution. Supply chain agility in turn is required to produce innovative products delivered in a timely manner to customers. Ojha, White, and Rogers (2013) investigated the effect of manufacturing flexibility on workflow and operational performance using data collected from US manufacturing firms. They found empirical evidence supporting that manufacturing flexibility has a positive effect on performance (lower inventories & costs). They have also found manufacturing flexibility to increase the speed of material flow (time). In this study, it is proposed that manufacturing flexibility is positively associated with operations performance. The rationale for such a proposal is the assumption that by building manufacturing flexibility firms are expected to better accommodate changing environmental conditions related to market and technological turbulence, thus, producing better outcomes in terms of time, cost, and quality inherent to manufacturing processes: *H3b: Manufacturing flexibility is positively associated with operations performance (time, cost, & quality).*

Lastly, in consideration of the aforementioned work of Wu (2006) that identified manufacturing flexibility as a mediating dynamic capability in the relationship between resources and performance, along with Patel, Terjesen, and Li (2012) that identified manufacturing flexibility as a mediator of the relationship between contextual ambidexterity levels and firm performance, the following mediation hypotheses are proposed: *M2a: Manufacturing flexibility mediates the relationship between knowledge creation and business performance; M2b: Manufacturing flexibility mediates the relationship between knowledge creation and operations performance (time, cost, quality); M2c: Manufacturing flexibility mediates the relationship between technological turbulence and business performance; and, M2d: Manufacturing flexibility mediates the relationship between technological turbulence and operations performance (time, cost, quality).*

Research Design and Measures

A survey directed to CEOs and CFOs, guaranteeing the respondent's anonymity, was sent by e-mail in 2014 to all 3728 Portuguese manufacturing firms with 20 or more employees registered in the Kompass International Neuenschwander SA database. There were 515 responses with 370 responses validated after checking for missing data, duplicate responses, and non-engaged response profiles, which is an effective response rate of 24.2% of the sample. Using a similar population of Portuguese manufacturing firms, Lages, Jap, and Griffith (2008) reported that for 1332 firms, 59% of the surveys were undeliverable. Based on the population of Portuguese firms with 20 or more employees according to Instituto Nacional de Estatística (2012), the sample used in this study represents 6.5% of the population.

Nonresponse bias was tested by comparing early and late responders (early respondents as the first 75% respondents to return the survey & late respondents as the last 25%) with respect to firm age and firm size. The lack of significant differences between the early and late respondents (Armstrong & Overton, 1977) suggests that response bias is not a relevant problem in this study. The correlation of responses for firm age and firm size with data from the firm's annual reports shows a significant correlation between data (0.718 for firm age, $p < 0.01$; 0.928 for firm size; $p < 0.01$).

To assess the impact of common method bias the Harman's one-factor test was performed, as well as the unmeasured latent methods factor test (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). Harman's one-factor test results show that no single major factor emerges from the analysis of all items in the model. The non-rotated free solution produces eight factors with eigenvalues greater than 1.0 that account for 71.8% of the total cumulative variance with the first extracted factor accounting for 29.4% of the variance in the data. Complementarily, the introduction of a common latent factor did not greatly affect the majority of the standardized loadings of each variable. These results suggest the absence of the common method bias.

This study adopts scales commonly used in the literature. The survey uses a seven-point Likert type scale with a range from strongly disagree (1) to strongly agree (7) for all non-demographic variables. Knowledge creation (KNOW CRE) was measured through four items, taken from Pavlou and El Sawy (2006), Prieto, Revilla, and Rodríguez-Prado (2009), as well as Flatten et al. (2009). Technological turbulence (TECH TURB) was measured through four items taken from Jaworski and Kohli (1993). Manufacturing flexibility (MAN FLEX) was measured using the scale developed by Rogers, Ojha, and White (2011), which conceptualizes manufacturing flexibility as a second order construct with six complementary dimensions measured through three items each: product-mix flexibility, routing flexibility, equipment flexibility, volume flexibility, labour flexibility, and supply chain flexibility. The construct designated in this study by operations performance (time, cost, & quality) was measured through three items proposed in this study, and assessing the relative performance of lead time to market, manufacturing flow cost, and production output quality level, when compared to the strongest competitors of each firm over a five year period (OPER PERF). Business performance (BUS PERF) was measured using four items from Gibson and Birkinshaw (2004), assessing business performance over a period of five years. Market turbulence (MKT TURB) was measured through four items, taken also from Jaworski and Kohli (1993). Table 1 presents a summary of descriptive statistics characterizing the main constructs in the measurement model: standard deviations, correlation matrix, reliability, and variance extracted estimates for main constructs.

Table 1. Std. Deviations, Correlations, Reliabilities, and Variance of the Constructs[1]

Construct	SD	Y1	Y2	Y3	Y4	Y5	CR	AVE
TECH TURB (Y1)	1.25	0.82					0.89	0.67
KNOW CRE (Y2)	1.05	0.30	0.83				0.89	0.68
MAN FLEX (Y3)	0.75	0.31	0.54	0.72			0.86	0.52
BUS PERF (Y4)	0.93	0.34	0.66	0.50	0.87		0.90	0.75
OPER PERF (Y5)	0.82	0.28	0.39	0.36	0.46	0.74	0.79	0.55

[1]Diagonal entries are the square root of AVE; SD = Standard Deviation, CR = Composite Reliability; AVE = Average Variance Extracted; Correlations result from CFA (measurement model).

Model, Mediation, Multi-Group Moderation

The purified measurement model reveals a composite reliability for all constructs above 0.70, the threshold in Hair, Black, Babin, and Anderson (2010), ranging from 0.79 for operations performance (time, cost, & quality) to 0.90 for business performance. The average variance extracted (AVE) was also above 0.50 for all constructs, ranging from 0.52 (manufacturing flexibility) to 0.75 (business performance). This shows the convergent reliability of the constructs. For all constructs, the average variance extracted (AVE) was greater than the maximum shared variance (MSV) and greater than the average shared variance (ASV). The square root of AVE was also greater than inter-construct correlations for all variables. Thus, the measurement model constructs do not display any discriminant convergence issues (Hair et al., 2010). The refined measurement model as presented in the previous section and without resorting to any error correlations between variable indicators, evidenced a fair model fit ($\chi^2 = 813.8$, Chi/df=1.94, CFI=0.940, TLI=0.934, NFI=0.885, RMR=0.144, RMSEA=0.051).

Structural Equation Modeling (SEM) was used to test the main hypotheses in AMOS IBM version 22. The model fit was fair ($\chi^2 = 811.5$, Chi/df=1.93, CFI=0.941, TLI=0.934, NFI=0.885, RMR=0.121, RMSEA=0.050). The model explains 45% of the variance of business performance, and 17% of the variance of operations performance (time, cost, & quality), the endogenous variables. Empirical support for all the six main hypothesis regarding the path coefficients of the model was found. Table 2 depicts the hypotheses tests results and the model fit.

Table 2. Main Hypotheses of the Structural Model Test Results[2] and Model Fit[3]

Hypothesis	Path	Stand. Coef.	S.E.	C.R.	*p*
H1a	TECH TURB → MANFLEX	0.168	0.035	2.856	**
H2a	KNOW CRE → MAN FLEX	0.455	0.049	6.663	***
H2b	KNOW CRE → BUS PERF	0.552	0.065	8.989	***
H2c	KNOW CRE → OPER PERF	0,276	0.057	3.808	***
H3a	MAN FLEX → BUS PERF	0.188	0.089	3.130	**
H3b	MAN FLEX → OPER PERF	0.197	0.057	2.603	**

[2]Tests of hypothesis are two tailed; * $p<0.05$, ** $p<0.01$, *** $p<0.001$; S.E. = Standard error; C.R. = Critical ratio; $p = p$ value; [3]model fit $\chi^2 = 811.5, df = 420; NFI = 0.885; TLI = 0.934; CFI = 0.941; RMSEA = 0.05$.

Table 3 presents the direct, indirect, and total standardized effects involved in all mediation hypotheses. The results support all the four mediation hypothesis proposed in this study.

Table 3. Mediation Hypotheses[4], Direct and Indirect Effects

Hypothesis	Mediator	Indirect Effect	Direct Effect	Total Effect
M2a	MAN FLEX	0.086 (0.011)	0.552 (0.002)	0.638 (0.003)
M2b	MAN FLEX	0.09 (0.042)	0.276 (0.002)	0.365 (0.002)
M2c	MAN FLEX	0.032 (0.018)	0 (-)	0.032 (0.018)
M2d	MAN FLEX	0.033 (0.043)	0 (-)	0.033 (0.043)

[4]Significance (in brackets) was obtained through the bias corrected percentile method (2-tailed); a 1000 bootstrap samples with replacement method, at a 90% confidence level, was used to compute the effects.

For multi-group moderation, Table 4 presents the structural model paths with significant z-scores differences detected.

Table 4. Multi-group Moderation[5] on Market Turbulence

Path	MKT TURB (L)	MKT TURB (H)	z-score
MAN FLEX → OPER PERF	0.060 (NS)	0.440 (0.004)	*
KNOW CRE → BUS PERF	0.746 (0,000)	0.392 (0.000)	**

[5]Z-score significances: * $p<0.05$, ** $p<0.01$, *** $p<0.001$. L = Lower Market Turbulence; H = Higher Market Turbulence.

Discussion and Implications

The positive direct impacts of knowledge creation on manufacturing flexibility, business performance, and operations performance are the most intense and present the highest statistical significance levels. But results also show an indirect positive impact of knowledge creation on business performance and operations performance through the mediation of manufacturing flexibility. Albeit less intense, such indirect impacts are also statistically significant. Beyond these effects, manufacturing flexibility exerts positive significant impact on both business performance and operations performance. Multi-group moderation analysis on market turbulence shows that the impact of manufacturing flexibility on operations performance is higher under higher market turbulence, a finding in line with Anand and Ward (2004) who have shown that manufacturing flexibility is a stronger antecedent of performance under higher turbulence. This study's findings are also in line with Lloréns, Molina, and Verdú (2005) underlining that both environmental factors and internal resources have an impact on flexibility. By confirming that technological turbulence produces a direct and significant positive impact on manufacturing flexibility, results suggest that technological turbulence can be regarded as a technological push for the development of manufacturing flexibility. This view is indirectly in line with that of Ahlström and Westbrook (1999) supporting that advances in manufacturing processes are directly related with mass customization. This represents an alternative to thinking about technological turbulence as a moderator. Having confirmed that technological turbulence has a positive indirect effect on both business performance and operations performance suggests that technological turbulence information is partly transformed into positive firm outcomes through manufacturing flexibility. Overall, the impacts of knowledge creation and technological turbulence on manufacturing flexibility are coherent with Spanos and Voudouris (2009), who concluded that among the antecedents of advanced manufacturing technology one can find developments in manufacturing capabilities, absorptive capacity, and environmental pressures. The fact that knowledge creation impact on business performance is considerably reduced under higher market turbulence suggests that knowledge creation effects may be curtailed under higher turbulent environments. A possible explanation for this is that higher turbulence could set a tougher competitive scenario in which resources and capabilities compete within the firm limiting the focus on higher-order dynamic capabilities and also its impact. This finding seems opposite to that of Drnevich and Kriauciunas (2011) who concluded that higher turbulence positively influences the effect of dynamic capabilities on relative firm performance. This incongruence may be related to what is being measured or the higher or lower order of dynamic capabilities specific considerations. Possible implications to management teams are manifold. First, managers should foster knowledge creation capabilities to develop manufacturing flexibility to levels adequate for coping with the firm's environment. Second, managers have to gain with a perspective of technological turbulence as an opportunity. The real threat and challenge could rather be internal inertia, as Rosenbloom and Christensen (1994) emphasized. Third, the impact of manufacturing flexibility on operations performance being more intense under higher market turbulence, shows that manufacturing flexibility is playing an important contingency-response role in the adaptability of firms to higher market turbulence. This study's results confirm Rogers, Ojha, and White (2012) in that cross training employees to adequately engage with different activities, different types of machines and diverse team's compositions positively affects the concept of manufacturing flexibility. As always, this study has limitations. First, cross-sectional analysis can only be considered a starting point of research. It would be ideal to distribute the survey at least at two different times. Second, the fact that a cross-sectional study is but a snapshot of the simultaneous occurrence of certain characteristics, causalities should be taken with caution and further tested by qualitative research. Third, it would be important to obtain secondary information or at least multi-respondent responses particularly for the cases of endogenous and exogenous variables. Finally, adopting flexible manufacturing does not guarantee, *per se*, improvements in firm performance if other mediating variables keep unaccounted for by managers (Camisón & Villar López, 2010).

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From project traceability to knowledge discovery: Case study on software design project

[Complete Research]

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Abstract

Knowledge management can empower a company to reuse knowledge gained from past experiences. There are already several approaches based on knowledge engineering methodologies that enable us to keep track of project knowledge, however, cooperative knowledge remains still a challenge for knowledge discovery due to its particular features: cooperative knowledge is produced from cooperative activities, which involves multiple individuals, no single actor can claim to explain globally the cooperative activity with no personal bias. One way to extract cooperative knowledge is through faceted classification of project trace. In this paper, one elaborated use case on software design will be demonstrated to show the cycle of cooperative knowledge discovery.

Keywords: Knowledge management, knowledge discovery, classification, project traceability, cooperative work, engineering design

Introduction

With the development of knowledge management, knowledge has become an important organisational resource that needs to be managed as other resources in a company. Recent knowledge management research has put more and more attention on the role of information technology in knowledge management. Information Technology (IT), once interlaced with organisational knowledge management strategies and process, is a powerful tool to support creation, codification, sharing and learning of knowledge in organisations (Alavi & Leidner, 2011; Holtshouse, Borghoff, & Pareschi, 2013). The general IT-supported knowledge management cycle can be divided into four major steps: capture organisational knowledge in a company, store the knowledge, share this knowledge among users, and employees will accomplish learning this knowledge by applying it (Evans, Dalkir, & Bidian, 2014; Dieng, Corby, Giboin, & Ribière, 1999). Traceability or keeping trace offers a good way to capture and store knowledge. A trace can be followed to discover or ascertain the course or the development of something. Several traceability-based techniques are developed and applied in several domains, for example profiling techniques for online user behaviour (Godoy & Amandi, 2005), and MEMORAE, an ontology-based annotation platform for knowledge capturing in an organisation (Abel, Lenne, & Cisse, 2002). A structured project trace can tremendously facilitate the process of knowledge discovery, since it offers high-quality structured data for classification.

Cooperative Knowledge and Knowledge Discovery

Nonaka (2007) and Spender (1996) emphasized that both individual knowledge and social knowledge exist in an organisation. Individual knowledge is created and resides in individual's mind, whereas social knowledge is created by and inherent in the collective actions of a group. In the case of cooperative work, on one hand each individual possesses expert knowledge, which is developed from one's professional practice and learning; on the other hand, social knowledge is created by collaboration. We define this kind of social knowledge as cooperative knowledge, produced by the interactions among individuals in a group in cooperative work. Due to the collective and collaborative dimension of cooperative work, cooperative knowledge is different from expert knowledge for two reasons: 1). The domain context of knowledge is different. Expert knowledge is related to one field and contains routines and strategies developed individually from experiences, while cooperative knowledge is multidisciplinary 2). The social context of knowledge is different. Expert knowledge resides in individual's mind; its social context is that of its producer's. However, cooperative knowledge cannot be restricted to a single actor, the social context of cooperative knowledge is related to the whole group's dynamics (Ackerman, Dachtera, Pipek, & Wulf, 2013).

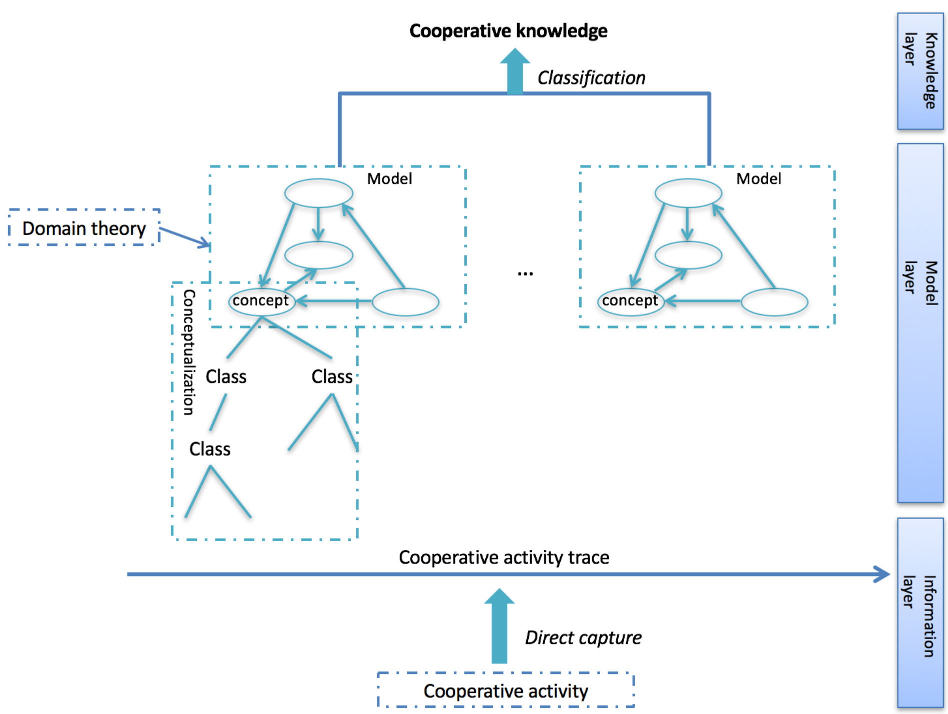

Figure 1. The Cooperative Knowledge Discovery (CKD) framework

Classification is the meaningful clustering of experience, it contributes to accumulate knowledge and shapes it into a powerful representation (Barbara, 1999). For expert knowledge, several knowledge engineering methods propose to extract knowledge from experts through interviews, documents analysis and modelling (Akkermans, Wielinaa, & de Hoog, 1994; Matta, Ermine, Aubertin, & Trivin, 2002) hierarchical classification is used to identify an object or phenomenon, while heuristic classification, which entails non-hierarchical direct concept association, represents the problem-solving (Newell, 1982). In face of the particular features of cooperative knowledge, it is argued that knowledge needs to be captured directly from cooperative work, and generalize knowledge by classification of repetitive patterns (DAI, Matta, & Ducellier, 2014). Fayyad Piatetsky-Shapiro, and Smyth (1996) employed the term "knowledge discovery in databases (KDD)" to describe the process mapping low-level data into other forms that might be more compact, more abstract, or more useful. One important aspect of KDD is to incorporate prior domain knowledge in data mining process. A cooperative knowledge discovery (CKD) framework was defined in DAI et al. (2014)'s previous work, the general framework is shown in the Figure 1. It consists of three layers: information layer, where project information is captured in a structured manner; model layer, where models are designed according to different types of knowledge in a specific domain; knowledge layer, where model instances will be generalized into abstract rules. It proposed faceted classification model on decision-making, project organisation, project realization, and project planning. Next this framework will be elaborated on two design projects.

Case Study Based on CKD

This case study consists of two software design projects, undertaken by two different groups of Master students of University of Technology of Troyes in the year 2012 and 2013. The tablet application MMrecord and MMreport (Bekhti & Matta, 2009) are used to capture the project meeting traceability in each group. The group members consist of students majoring in computer science and students majoring in mechanical design. The 2012 project involves eight students, among whom four major are in computer science and four in mechanical design, and for project 2013, five students participated, three of them major in computer science and two major in mechanical design. The goal of this project is to design a tablet application, which aids a mechanical technician in product maintenance. An evaluation of project result shows that the first project failed because it does not respect the project budget, and the second one succeeded to meet all the project specifications. We collected the recording of their work meetings from MMreport and their project report. Next two classifications will be shown according to CKD.

Problem-Solving Knowledge

One similar issue that both groups tackled in their projects is to define the function of this application. The decision-making processes of both groups on this issue are put in tables as follows (Table 1).

Table 1. Decision-making on the issue “function definition” of project 2012 and project 2013

<table>
<tr><th colspan="4">Project 2012 Tablet Application for Product Maintenance Issue: Function Definition</th></tr>
<tr><td>Proposition</td><td colspan="2">Argument</td><td>Decision</td></tr>
<tr><td rowspan="4">Automatic object recognition by image to detect product</td><td rowspan="2">defend</td><td>Improve efficiency</td><td rowspan="12">Automatic object recognition by image

Four databases

Information exchange between the application and ERP, PLM</td></tr>
<tr><td>Easy access</td></tr>
<tr><td rowspan="2">criticize</td><td>Increase budget</td></tr>
<tr><td>Complex development</td></tr>
<tr><td rowspan="3">Single database for all modules</td><td rowspan="2">criticize</td><td>Need data synchronization</td></tr>
<tr><td>Create data redundancy</td></tr>
<tr><td>defend</td><td>Easy administration</td></tr>
<tr><td>Four databases, one for each module</td><td colspan="2">Null</td></tr>
<tr><td rowspan="2">Information exchange between ERP and PLM</td><td>defend</td><td>Reduce data redundancy</td></tr>
<tr><td>criticize</td><td>Technological obstacle</td></tr>
<tr><td>Information exchange between the application and ERP, PLM</td><td colspan="2">Null</td></tr>
<tr><td colspan="3"></td></tr>
<tr><th colspan="4">Project 2013 Tablet Application for Product Maintenance Issue: Function Definition</th></tr>
<tr><td>Proposition</td><td colspan="2">Argument</td><td>Decision</td></tr>
<tr><td rowspan="2">Manuel search for concerning knowledge for problem</td><td>defend</td><td>Easy implementation</td><td rowspan="6">Manuel search for knowledge of concerning product

Single database

Information exchange between the application and ERP, PLM</td></tr>
<tr><td>criticize</td><td>Requires users to have certain mechanical knowledge</td></tr>
<tr><td rowspan="3">Single database for all modules</td><td rowspan="3">defend</td><td>Centralized administration improve searching</td></tr>
<tr><td>Secure information confidentiality</td></tr>
<tr><td>Evade frequent communication among the modules</td></tr>
<tr><td>Information exchange between the application and ERP, PLM</td><td colspan="2">Null</td></tr>
</table>

With the same project specification, on the same issue “function definition”, decision-making produces different outcomes. According to the classification rule, similar decisions will be classified as essential solutions; similar propositions that are excluded from essential decisions will be classified as conditional solutions; unique propositions will be classified as explorative solutions. Arguments will be combined and attached to decisions and propositions as explanation. And a weight factor W_i will be attached to each concept to indicate its importance, this factor increases by one each time a similar instance is classified. The classification result in shown in Table 2.

Table 2. Classification result of the issue "function definition"

Project of Tablet Application Design for Product Maintenance Issue: Function Definition			
		Argument	
Essential solutions	Information exchange between the application and ERP, PLM (W_1=1)	Null	
Conditional solutions	Automatic object recognition by image (W_2=0)	defend	Improve efficiency (W_{21}=0)
			Easy access (W_{22}=0)
		criticize	Increase budget (W_{23}=0)
			Complex development (W_{24}=0)
	Manuel search for concerning knowledge for problem (W_3=0)	defend	Easy implementation (W_{31}=0)
		criticize	Requires users to have certain mechanical knowledge (W_{32}=0)
	Single database for all modules (W_4=1)	defend	Centralized administration improve searching (W_{41}=1)
			Secure information confidentiality (W_{42}=1)
			Evade frequent communication among the modules (W_{43}=1)
		criticize	Need data synchronization (W_{44}=1)
			Create data redundancy (W_{44}=1)
	Four databases, one for each module (W_5=0)	Null	
Explorative solutions	Information exchange between ERP and PLM (W_6=0)	defend	Reduce data redundancy (W_{61}=0)
		criticize	Technological obstacle (W_{62}=0)

In the classification result, we can see that the similar decision "the connection between the application and ERP, PLM" is classified as the essential solution for the issue "function definition". The other similar propositions are about two aspects: the search function and database design, they are regarded as conditional solutions. One proposition is unique, "connection between PLM and ERP", it is put aside as explorative solution for future classification. Conditional solutions are solutions we need to consider with respect to their risks. For example, the conditional solution "automatic object recognition by image" is the reason why the first project failed to satisfy the project budget, but in another project, with a more generous budget, this solution might be very useful. The classification result of the problem solving process on this issue may improve the decision-making for another similar situation.

Management Knowledge

The management knowledge tries to reveal the social influence on decision-making and project realization. Here we want to examine how competences of actors influence their behaviours in the decision-making process above. In both of the projects, they choose the same organisation divisions according to three functions: ERP, PLM, and Tablet application. However, in each group, the competence distribution is not different. We define the logic predicate (Ar_{ij}, competence, organisational_division) to represent the actors and their properties. If we add social context into the decision-making, it can be written in a table as follows in Table 3.

Table 3. Decision-making on the issue "function definition" with social context

Project 2012 on Tablet Application for Product Maintenance Issue: Function Definition			
Proposition	Argument		Decision
Automatic object recognition by image to detect product *[Ar_{12}, Computer_science, APP_division]*	defend	Improve efficiency *[Ar_{11},Computer_science,APP_division]*	Automatic object recognition by image *[Ar_{12}, Computer_science, APP_division]* Four databases *[Ar_{11},Computer_science,APP_division]* Information exchange between the application and ERP, PLM *[Ar_{16},Mechanical_design,ERP_division]*
		Easy access *[Ar_{11},Computer_science,APP_division]*	
	criticize	Increase budget *[Ar_{15},Mechanical_design,ERP_division]*	
		Complex development *[Ar_{15},Mechanical_design,ERP_division]*	
Single database for all modules *[Ar_{13},Computer_science,APP_division]*	criticize	Need data synchronization *[Ar_{12}, Computer_science, APP_division]*	
		Create data redundancy *[Ar_{12}, Computer_science, APP_division]*	
	defend	Easy administration *[Ar_{13},Computer_science,APP_division]*	
Four databases, one for each module *[Ar_{11},Computer_science,APP_division]*	Null		
Information exchange between ERP and PLM *[Ar_{16},Mechanical_design,ERP_division]*	defend	Reduce data redundancy *[Ar_{16},Mechanical_design,ERP_division]*	
	criticize	Technological obstacle *[Ar_{14},Computer_science,APP_division]*	
Information exchange between the application and ERP, PLM *[Ar_{17},Mechanical_design,PLM_division]* *[Ar_{15},Mechanical_design,ERP_division]* *[Ar_{16},Mechanical_design,ERP_division]*	Null		

<table>
<tr><th colspan="4">Project 2013 on Tablet Application for Product Maintenance Issue: Function Definition</th></tr>
<tr><td>Proposition</td><td colspan="2">Argument</td><td>Decision</td></tr>
<tr><td rowspan="2">Manuel search for concerning knowledge for problem [Ar_{21},Computer_science,APP _division]</td><td>defend</td><td>Easy implementation [Ar_{23},Computer_science, ERP_division]</td><td rowspan="6">Manuel search for knowledge of concerning product [Ar_{21},Computer_science,APP_divi sio]

Single database [Ar_{21},Computer_science,APP_divi sio]

Information exchange between the application and ERP, PLM [Ar_{23},Computer_science, ERP_division]</td></tr>
<tr><td>criticize</td><td>Requires users to have certain mechanical knowledge [Ar_{24}, Mechanical_design, APP_division]</td></tr>
<tr><td rowspan="3">Single database for all modules [Ar_{21},Computer_science,APP _divisio]</td><td rowspan="3">defend</td><td>Centralized administration improve searching [Ar_{21},Computer_science,A PP_divisio]</td></tr>
<tr><td>Secure information confidentiality [Ar_{25}, Mechanical_design, PLM_division]</td></tr>
<tr><td>Evade frequent communication among the modules [Ar_{22},Computer_science, PLM_division]</td></tr>
<tr><td>Information exchange between the application and ERP, PLM [Ar_{22},Computer_science, PLM_division] [Ar_{23},Computer_science, ERP_division]</td><td colspan="2">Null</td></tr>
</table>

By comparing these two model instances, we can relate an actor's competence with different types of proposition or argument. Actors with competence computer science make all the IT implementation propositions; all the usability-oriented arguments are from actors with competence mechanical design; decisions about a specific function are made by actors within the organisational division on the same function. We note especially for the proposition "automatic object recognition by image to detect product", it is made by $Actor_{12}$ with computer science background, in the tablet application development division. Another actor with mechanical design background from the ERP division criticizes this proposition, but this proposition is still taken as decision, which leads the project failed by exceeding the project budget. But in another project, a more balanced proposition "manual research pertinent knowledge" was made by the actor from tablet application development division, which meets the project specification within project budget. We may assume that the variety of competences in a group can push ideas form different points of view to confront each other, which may lead to a balanced solution.

Case Analysis

In this case study, students followed our indications to keep track of their cooperative work. So, we succeeded to build links between collaborative decision-making and project organisation. We applied two of our classification rules: problem solving rule that points out essential solutions and conditional solutions for a problem, and management rule that shows organisational influences on decision-making. The weight factor is a useful indicator to show the importance of each element. More importantly, the arguments are classified and attached to solutions, which explain the advantages, disadvantages or conditions for the solutions. The classification of decision-making in social context enables us to learn how organisation influences decision-making. In this case, management classification shows that multi-disciplinary organisation inclines to engage into cooperative work, designing a relatively balanced solution that responds to most of project goals. The result of this example proves that cooperative knowledge can be discovered from structure project trace, and this knowledge is semantically useful and can be applied and learned.

Conclusions

In this paper, we argued that a different approach is required to obtain cooperative knowledge due to the collaborative and collective features of cooperative work. Project traceability is important to show a structured evolvement of project events, which serves as a good database for knowledge discovery. An elaborated example was shown and analysed based on the CKD framework, problem solving knowledge and management knowledge were generalized. This case study proved the plausibility to discover cooperative knowledge from cooperative work through classification. However, a larger database is required to improve the accuracy and applicability of the cooperative knowledge.

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Evaluation of the business information search using semantic network as a visual interface

[Research-in-Progress]

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Abstract

Economic and financial indicators provide much information concerning the functioning of an enterprise. Their usefulness depends also on decision-makers' comprehension of structural and semantic connections existing between indicators. A semantic network based on the ontology of economic and financial indicators can allow its users to more swiftly notice and understand various relations. A visualization of semantic network can serve as an interactive visual interface that allows decision-makers to search for information. The aim of this study is to validate the usability of the business information search using semantic network. We used a questionnaire of user interface satisfaction and a usability test for evaluating the efficacy of user interfaces. This study was executed according to our proposed research method, described herein. The evaluation of two visualization prototypes was carried out with participation of volunteers. In this paper we analyze the results of this experiment.

Keywords: user interface, visual interface, semantic network, usability, visualization, ontology of business knowledge

Introduction

Economic and financial semantic network visualization can provide valuable assistance for analysis of economic data and decision-making. The usefulness of economic and financial indicators in decision-making depends on managers' accurate understanding of both logical effect of these indicators and semantic relationships between them. During the analysis of economic and financial indicators managers often use different analytical programs (including Business Intelligence systems). Evaluation of the Information Technology made that managers have multidimensional access to more and more numerous data stored in various databases and the possibility of their multi-criteria processing. However, available solutions concerning the analysis of economic and financial indicators focus on delivering the information reflecting hierarchic relationships between considered metrics. However, managers are also expecting to be able to analyze those metrics in terms of the existing contextual relationships between them.

Visualization of semantic relationships between economic and financial indicators can allow users to more swiftly notice and understand various relationships. This requires research and analysis of the visualization technique's usability. Shneiderman (1998) defined five metrics that are essential in studying such a system's usability: (1) system familiarity time, (2) task performance speed, (3) errors in task assignments, (4) system feature retention, and (5) subject satisfaction.

Information search within a semantic network is a subject of many studies and is a concern of various fields (Hirsch, Hosking, & Grundy, 2009; Khalili & Auer, 2014; Korczak, Dudycz, & Dyczkowski, 2012; Stab, Nazemi, Breyer, Burkhardt, & Kohlhammer, 2012; Yi, 2008). In this study, special attention is paid to the role of visualization in regard to semantic networks. The combination of semantic network visualization and user navigation can be an effective and efficient tool for various analyses, including that of business data.

We are carrying out the research on the use of visualization methods in searching business information (especially in Business Intelligence systems) basing on a semantic network. Ontology is inter alia the basis of collecting and searching data in semantic network. In this approach the special attention is paid to the role of the visualization of a semantic network which is not only a tool for presenting data, but also provides an interface allowing for interactive visual information searching (Grand & Soto, 2010; Wienhofen, 2010). However, research efforts in ontology visualization have largely focused on developing new visualization techniques rather than improving the usability of existing ones (Fu, Noy, & Storey, 2014). Evaluation of visualization techniques in the context of ontology-focused tasks has been limited (Fu, Noy, & Storey, 2013).

In the present paper we will focus on the use of visualization method in business information that was organized within a semantic network. In previous studies, we have presented the procedure of creating an ontology of economic indicators (Dudycz, 2012), the process of conceptualizing of an ontology of chosen economic and financial indicators (Dudycz, 2015a), and a usability evaluation of economic and financial semantic search visualization (Dudycz, 2012; Dudycz, 2015b). The main goal of this paper is to discuss the research on evaluation of semantic network using to search for business information. In this research, two data collection methods were used: (1) a user questionnaire on user interface (UI) satisfaction, and (2) a usability test. Following this introduction, we briefly describe semantic networks as a visual interface, then present assumptions of our research and obtained results, and finally, we summarize this work, and present our findings.

Semantic Network as a Visual Interface

The use of graphical interfaces is a primary characteristic of the new generation of systems that is dedicated for decision-makers. One of the ideas for collecting and searching data is semantic network which besides the data themselves contains also information on relations between them. A semantic network (also called semantic net or concept network) "is a graph structure for representing knowledge in patterns of interconnected nodes and arcs" (Sowa, 1992, p. 1). It is a directed or undirected graph, where vertices represent concepts and edges represent relations between concepts. One of the main artefacts in semantic networks is the ontology. In literature many different definitions of ontology can be found. Smith (2010) presented a wide review of this issue. However, there is no universally used one in information technology. Most often quoted definition of ontology formulated by Gruber (1993) is, "[ontology] is an explicit specification of a conceptualization" (p. 907). The hallmark of a semantic network is a robust ontology wherein data and relationships of objects from various fields of knowledge are defined. In this study, special attention is paid to the role of semantic network visualization, which is a multi-faceted, interactive presentation tool and also allows for interactive visual searching for information (Grand & Soto, 2010; Wienhofen, 2010). There is a new term used to describe technologies associated with ontology and visualizing of semantic structures search: "Semantics Visualization" (Nazemi, Breyer, Burkhardt, Stab, & Kohlhammer, 2014, p. 192). In recent years, researchers have developed a variety of techniques to visually present ontologies (Fu et al., 2013; Garshol, 2004; Lanzenberger, Sampson, & Rester, 2010).

The combination of data visualization in the form of semantic network and personal navigation can become an effective and efficient tool to perform various analyses, including economic data. The interface is described as good because it has the proper presentation and efficient navigation allowing users to quickly access the information they need (Hunting & Park, 2002). Used presentation of data has a major impact on the way in which for example decision-makers interpret the data and assess the usefulness of the system. For users the presentation layer is the most critical element of information and analytical system because it largely shapes the understanding of the basic data on the computer screen (Wise, 2008).

Visualization of semantic searches is essential, as it allows users to more easily notice and understand various semantic and structural dependences between topics. With visualization of semantic structuring of topics, it is possible to interactively choose analyzed topics or relations and change the focus of presented details. Fu et al. (2013; 2014) focused on evaluation of usability of two popular ontology visualization techniques: indented tree hierarchies and graphs. The main conclusions of their studies were: the graph visualization is more controllable, intuitive and more suitable for overviews than indented tree hierarchies (Fu et al., 2013; 2014).

A good visualization interface represents data in a way that helps users identify interesting sources, and allows users to efficient navigate information (Hunting & Park, 2002). The basic assumption of navigation is that it should allow users to look at fine-detail (focused) information and full-system context simultaneously, thereby presenting an overview of the whole knowledge structure (Smolnik & Erdmann, 2003).

Fundamental factors for a good semantic network visualization interface are: (1) full overview of the structure for understanding of the global hierarchy and of the relationships within; and (2) the ability to zoom and to select specific nodes (Dudycz, 2015b). Interactive visualization actively includes the user in the process of finding information, enabling him or her to build more accurate queries for a specific set of data (Lopes, Pinho, Paulovich, & Minghim, 2007), and facilitates the observation of data relationships. Visualization allows users/decision-makers to use their natural spatial/visual capabilities to determine where further exploration should be done

(Dudycz, 2010). Graphical presentation of data supports innovation by users (i.e. decision-makers), allowing them to formulate and validate new hypotheses. Graphical expressions may also assure that semantic information searches are interpretable for non-technical users.

Assumptions of the Research

The goal of our research is the evaluation of semantic network when using it to search for business information, based on the applications that contain the models of knowledge of the analysis of economic and financial indicators. This study has been carried out in the three stages (Figure 2):

- Stage 1: the ontology for the selected analysis of economic and financial indicators is created;
- Stage 2: the application for a specific field of analysis of economic and financial indicators is created;
- Stage 3: the usability of semantic network when using it to search for business information, is verified.

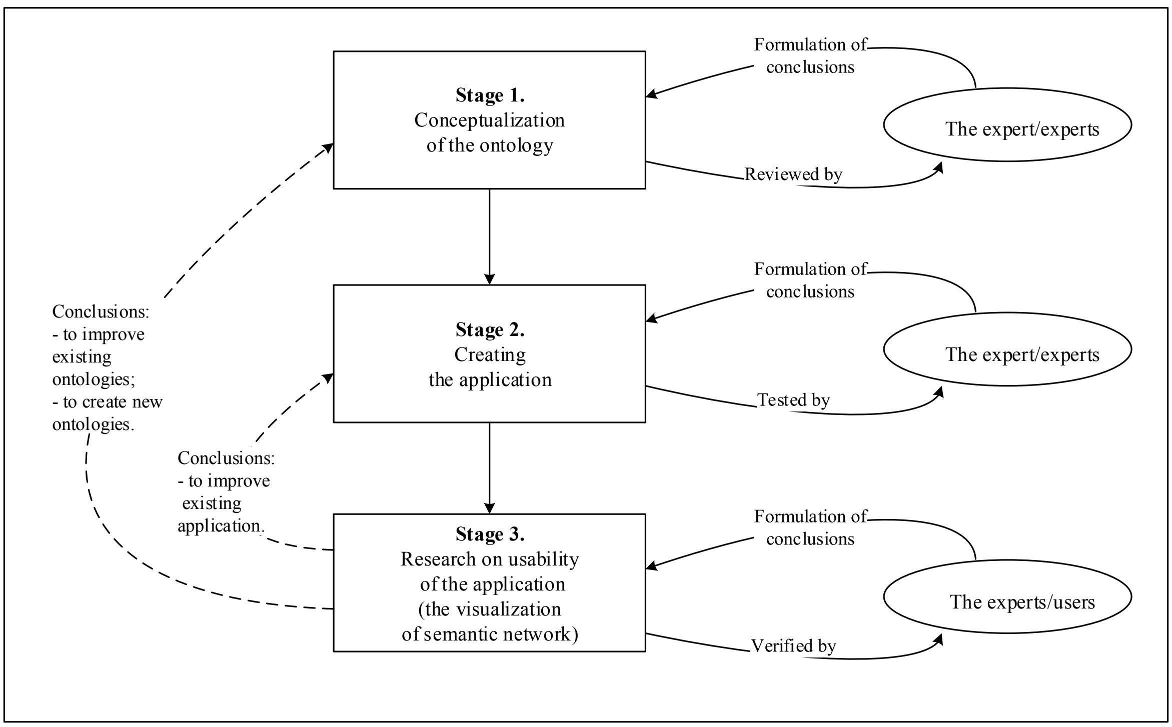

Figure 1. The scheme of the design of research on the evaluation the visualization of semantic network using in the searching the business information

Between stages there was feedback to improve the prototype. Conclusions from the third stage influence the improvement of the created ontology and the application for the analysis of economic and financial indicators. This approach to evaluation of the interface provides precise identification of the users' needs, and may contribute to the development of innovations. One of the important questions is: "Is semantic search visualization of business information a useful interface for managers?" For this study, it was essential to get answer to this question. In this paper we focus on the presentation of the research conducted in the stage 3. Our research was also to tell how easy and clear it is to search for information with the use of the visualization of the semantic network for a user who is not familiar with this kind of the visual interface.

In the evaluation of visualization of business information search results, information retrieval speed, errors in interpretation of data (errors in task assignments), and subject satisfaction are considered to be paramount. In the relevant literature, many methods to evaluate system usability and human-computer interactions are described (Lazar, Feng, & Hochheiser, 2010; Sikorski, 2012; Tullis & Albert, 2008). The research of a prototype can be conducted with participation from experts (e.g. heuristic evaluation, inspection-based evaluation) and/or users (e.g. usability testing, task-based experiment, eye tracking). We used a combination of two methods to evaluate UIs: (1) a questionnaire of UI satisfaction based on evaluation checklist, and (2) usability tests. This combination of techniques was chosen in order (1) to identify as many usability problems as possible, (2) to better understand why users experience these problems, and (3) to find solutions to these problems. This combination of methods is commonly used for these types of evaluations (Bakalov, König-Ries, Henning, & Schade, 2011). The questionnaire is designed to get the user's subjective opinions, whereas the usability tests are intended to reveal how users can achieve their goals with this interface and what difficulties they encounter.

We executed four experiments which differed in: (1) the prototype that was used by the participants during the study, (2) the tasks to be performed, and (3) time and content of training provided prior to the realization of commands. The fourth experiment was realized according to the following plan:

1. Define tasks for the usability test, and write questionnaire of user interface satisfaction.
2. Perform study with participation of users:
   a) select research participants,
   b) perform study with each participant:
      1) perform tasks using the application for the Return on Investment indicator (six tasks),
      2) perform tasks using the application for then the multidimensional early warning system (seven tasks),
      3) rate the interface based on evaluation checklist.
3. Analyze data with the following criteria:
   a) correctness of performing tasks,

b) ease of finding information,
c) interface usability,
d) identification of potential difficulties connected with used human-computer interactions.

4. Discuss results and conclusions.

In experiment four, the structure of the questionnaire was as follows:

1. User profile.
2. Tasks to be performed in the application for the Return on Investment indicator.
3. Tasks to be performed in the application for the multidimensional early warning system.
4. Evaluation by the users of criteria of the interface.
5. List of potential problems.

In experiment four, we used two applications that were built in Protégé (*How to Cite Protégé*, 2013): one that was for analysis of a Return on Investment (ROI) indicator (according to a Du Pont model), and one that was for a multidimensional early warning system (MEWS). The created applications differed in scale of solution, which is important for verifying the usage as a visual tool of searches of semantic connections. In the case of the ROI indicator prototype, the ontology consisted of 44 topics, six taxonomic classes (with relational types of "Subclass-Of"), and 13 binary relationships. In the multidimensional early warning system, the ontology consisted of 142 topics, 23 classes (with relational type of "Subclass-Of"), and 20 binary relationships. Both of the prototypes were evaluated based on user participation. There were 41 participants, who were 23-27 years old. These participants had varied knowledge of economics, and information technology (IT). In addition, they indicated in their questionnaires whether their current interest is more toward IT issues, economic, or both. The participants self-assessed current knowledge of economics, and IT in the first part of questionnaire. None of the participants were familiar with the Protégé program and had searched for information via ontological visualization prior to the study. These participants studies took place at the Wrocław University of Economics.

In this study, evaluation of semantic network visualization was conducted using the OntoGraf module (Falconer, 2016) in the Protégé 4.1 beta program. The various visualization plugins developed for the Protégé ontology editor are used in many studies for the visualization of ontology (Sivakumar & Arivoli, 2011).Our goal with regards to the OntoGraf module – which proved to be sufficient for the initial research – was to verify the usefulness of semantic network visualization in searching for business information that is contextually connected.

Findings

Results of finding business information

Participants performed the tasks in this experiment with the OntoGraf module in Protégé 4.1 beta application only. In the experiment 4, we adopted a rule not to explain to participants of the study how to search for information using visualization of semantic network. Introduction to this experiment took about 10-15 minutes during which we mainly discussed issues related to Protégé 4.1 beta. In this study, each participant first performed tasks using the application for the ROI indicator, and then one for the MEWS. The second and third parts of the questionnaire contain a task list. The participants had to enter the answer for each task. In order to do that they had to find information using the semantic network visualization. Figure 2 presents a sample visualization of a business knowledge semantic network search. The screenshot shows the expansion of the selected topic: *Return on Investment*, which is highlighted on the diagram with a green border. We planned out 60 minutes on performing all assignments by the participants. Many participants finished performing tasks and filling in questionnaires in shorter time. The research was not recorded by video camera, but during performing tasks participants were observed and their remarks were noted.

In the present paper we will focus on analyzing the results of correctness of performing tasks in both applications (for the ROI & for the MEWS). We have ordered tasks in questionnaires from the easiest to perform in our opinion to the hardest. Furthermore, we have prepared several sets of tasks which were identical with respect to the requirements related with realizing information searching operations, and they varied in e.g. search name or analyzed economic indicator. In Table 1 we presented data concerning correctness of performing tasks with the use of the ontology application for the ROI indicator and the ontology application for the MEWS. We analyzed the data obtained from this experiment with participants grouped into sets based on their knowledge and experience: (1) only familiar with economics, (2) only familiar with IT, and (3) familiar with both economics and IT. We emphasized in it predominant value for every task on the ground of the correctness of performing tasks. On the basis of the data analysis included in the table we formulate four conclusions.

First, the participants performed tasks for the MEWS significantly better than those for the ROI indicator. Potentially it was possible to expect that it is more difficult to find needed information using visualization of semantic network by using the second application as it is several times bigger. Participants of the experiment could not compare the answers for performing tasks because only after returning the questionnaire with tasks for the application for the ROI they received the questionnaire with tasks for the application for the MEWS. This follows the conclusion that short use of visualization of semantic network is enough, without long time-absorbing trainings in order to understand the idea of working the visualization of semantic network as an interface.

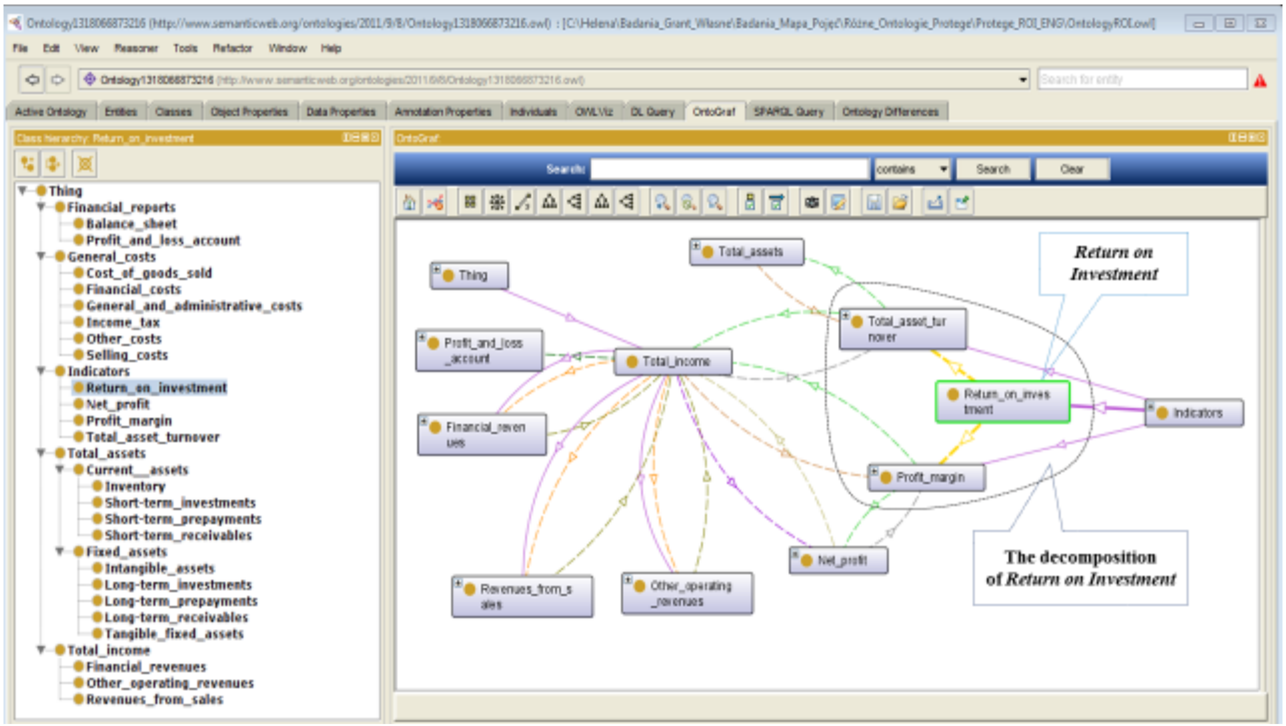

Figure 2. An example of semantic network visualization of business knowledge

Second, there is a small percentage of tasks which were made incorrectly for the application for the MEWS. While in the case of performing tasks by using an ontology application of the ROI indicator in column *All participants*, none of the tasks were *done well* in 100%, then in case of MEWS two tasks all made in 100% *well*. In this part the worst performed task was B.2. Moreover, the analysis of data considering education shows that participants with IT education made all tasks for the application of MEWS in 100% *well* and with economic education except one task (B.2) they performed also all in 100% *well*. These data are promising and indicate usefulness of semantic network visualization in searching for business information.

Third, task A.3, which was correctly performed only by 32% of all participants, requires a comment. The task was performed the best by the participants with IT education (64%). Attention should be paid to the fact that the participants with IT education did not achieve 100% correct only for this one task (from all 13). Only 25% of participants with IT education provided correct answers. Precise analysis of the answers demonstrated that the participants often included in the answer both correct terms having an impact on calculating indicator mentioned and two additional terms which were related semantically with it. The percentage of those, so called, oversized answers was 63%, whereas the percentage of other wrong answers was only 5%. In case of participants with IT education and economic education occurred only answers classified to *well* or to *oversized*. From this data comes the conclusion that with such a high percentage of good answers provided by people with economic education in comparison to other participants as well as to other tasks it is important to have knowledge from particular field for which the ontology was built.

Table 1. Tasks to be performed by users and evaluation of their accomplishment

Tasks	Accomplishment of tasks	Breakdown of accomplishment of tasks (%)			
		All participants	Participants with a background		
			IT	Economic and IT	Economic
A. The application for the ROI indicator					
A.1. How many ratios is a given indicator related with?	Done well	**95**	**100**	**96**	**91**
	Done wrongly	5	0	4	9
A.2. Give names of these ratios (from the task no. 1)?	Done well	**90**	**100**	**92**	**82**
	Done wrongly	10	0	8	18
A.3. Which ratios are basis of counting given indicator?	Done well	32	25	19	**64**
	Done wrongly	**68**	**75**	**81**	36
A.4. What arithmetical operation is performed in order to calculate given indicator (from the task no. 3)?	Done well	**66**	**100**	**54**	**82**
	Done wrongly	34	0	46	18
A.5. Topic _____ is in relation of type ____ with other topics. Write with how many.	Done well	**88**	**100**	**88**	**82**
	Done wrongly	12	0	12	18
A.6. Give names of these topics (from the task no. 5)? Write their names.	Done well	**83**	**100**	**85**	**73**
	Done wrongly	17	0	15	27
B. The application for the MEWS					
B. 1. Indicator ____ is a quotient of two other economic topics. Write their names.	Done well	**100**	**100**	**100**	**100**
	Done wrongly	0	0	0	0
B.2. What arithmetical operation is performed in order to calculate given indicator?	Done well	**90**	**100**	**88**	**91**
	Done wrongly	10	0	12	9
B.3. Topic _____ is in relation of type ____ with other topics. Write with how many.	Done well	**98**	**100**	**96**	**100**
	Done wrongly	2	0	4	0
B.4. Give names of these topics (from the task no. 3)?	Done well	**95**	**100**	**92**	**100**
	Done wrongly	5	0	8	0
B.5. Give the number assigned to the indicator.	Done well	**100**	**100**	**100**	**100**
	Done wrongly	0	0	0	0
B.6. Give the name of the indicator which is the numerator in a given ratio.	Done well	**95**	**100**	**92**	**100**
	Done wrongly	5	0	8	0
B.7. Write a model of the Z-Score for predicting bankruptcy.	Done well	**93**	**100**	**88**	**100**
	Done wrongly	7	0	12	0

Fourth, it is worth drawing attention to performing task B.7, which was to write down the formula of scoring model. This task required analysis of the semantic network where a lot of terms needed to be displayed in order to be able to recreate this model. Despite labor intensity related to performing this task very good results were received, i.e. 93% of the participants have given the correct answers. For this task, after distributing the questionnaire for MENS, we explained to the participants how the general formula of the scoring model looked. This follows the conclusion that the visualization of the ontology of economic knowledge, especially concerning economic analysis, could be a useful interface in searching needed information because of semantic relationships between different terms and indicators for persons owning knowledge from this field. Overall the obtained data was very promising in the context of evaluation of usefulness of semantic network visualization as an interface in searching for business information according to the context.

Summary of findings

Although the application for the ROI indicator is smaller in scope and, as such, theoretically easier than that of the MEWS, success rate of the task was significantly smaller. In the case of the application for the ROI indicator the correct performance of six tasks (which consists of searching for proper information) is shaped in the range of 32 to 95%. However, for the application for MEWS, where participants performed seven tasks, it is in the range of 90 to 100%. In our opinion, the participants "discovered" how to use the interface in a relatively short period of time. Analysis of these data indicates that only minimal use, without exhaustive training, is sufficient for users to understand how to access the data within the semantic network via this visualization interface.

Two conclusions were drawn from our research. First, the proposed way of searching for information can be a useful solution for decision-makers carrying out an analysis of economic indicators. Second, a user will learn how to access information within a semantic network with relative ease and quickness.

Conclusions

In this article, we introduce the results of our research to validate the business information search using semantic network. We focused on searching needed information related to analysis of economic and financial indicators. We presented the research protocol and discussed the obtained results. It should be noted that in experiment four we adopted a policy of not explaining to the participants how to search for information using semantic network. In the context of the assumptions the results of evaluation of the business information search using semantic network are promising.

We propose to support decision-makers by enhancing economic and financial indicator analysis with visualization of search results of semantic networks. Our study indicates that such visualization can be a useful tool for users, which makes interpretation of semantic accessible to non-technical users. Thanks to visualization, users can more swiftly notice and understand various structural and semantic relationships. Properly adopted visualization improves the perception of necessary information, which consequently enables users to make the right decision more quickly.

In the next experiment, we shall expand the ways of finding information via using two solutions: indented tree hierarchies and graphs. We hypothesize that the combination of these two techniques will make the user more effective at semantic searches of business information. In the experiments of this study, participants primarily used a network map. This research will be continued in order to validate the usefulness of the strengths and weaknesses of visualization interface for semantic searches of business information by decision-makers. We will also work to prepare the relevant design guidelines of visualization using the semantic network in business information search.

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Knowledge and innovation roles in business partnerships: The case of the Portuguese insurance sector

[Complete Research]

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Abstract

This paper explores the collaborative system of the Portuguese insurance sector, including the network space where different types of entities are inter-connected in order to offer high-valued services. We focused on a Knowledge and Innovation Management approach in order to measure the degree of collaborative maturity in insurance business partnerships and their ability to create value. Considering the data collected, our analysis identified low levels of maturity in knowledge management (KM) processes, insufficient open innovation, a lack of external network connections and obstacles associated with intersystem network control. Evidences of a strategic gap were also collected. Current relationships are forged under "the strength of weak ties", not suitable to nurture trust and socialization, which are critical to knowledge creation. Therefore, there are opportunities to stretch the complementary knowledge of business partners in order to create value. This exploratory study suggests that a Knowledge and Innovation view could enhance service differentiation but demands a proper engagement approach where social ties are paramount to success. Managers should be aware of this challenging transformation path in order to achieve strategic advantage through business networks.

Keywords: Business networks, collaborative partnerships, knowledge management, innovation, trust, service management, insurance management

Introduction

The technological development we see nowadays is the fastest in our history and the access to information, the forerunner of knowledge, influences the workings of society and the economy while strongly impacting the corporate arena. In the current era of dependence on information, knowledge and networks, collaboration capacity emerges as a critical business dimension. In such a fast-changing environment, the fundamental logic of value creation is moving from an internal and delimited view to a more complex and open competitive value system (Castels, 2002; Nambisan & Sawhney, 2011). Enterprises are not self-sufficient and their business results and competitiveness are interdependent from the competitive strength of their business partners. (Ford, Gadde Hankanson, & Snehota, 2002). In this value system view, knowledge and relationships are sources of competitive advantage (Norman & Ramirez, 1993). Accordingly, Knowledge Management (KM) in business networks has become central to competitiveness and differentiation, while its growing importance is connected with a dynamic view of market opportunities (Jarvenp, 2014; Nooteboom, 2006). In the context of networks, socialization among peers and collaborative work is of paramount importance in developing new products or services with competitive benchmarks that measure innovation. Although diversity of knowledge provides the possibility of the generation of new ideas innovation goes beyond the potential of any one firm, but requires collaborative working and social ties that permit interaction, along with a forum for collaborative learning. In this context, management should have instruments to assess collaborative maturity, focusing on Knowledge and Innovation processes. The insurance sector is a hub of business networks that adheres to the value system concept, where Knowledge and Innovation are critical to business transformation and strategic advantage. However, the question remains: Is Knowledge being strategically managed in these partnerships? How should managers explore unique partners' knowledge towards insurance innovation? How can they exploit Knowledge and Innovation in partnerships? In this paper, we start from the generic management problem of exploring the dynamics of collaborative business relationships towards value creation. In the Literature Review section, we present main concepts covering business networks, knowledge and innovation. Considering our collaborative approach, specific objectives and propositions are stated considering the specificities of the insurance business sector. In the Model of Analysis, our framework is briefly presented capturing the complex relation between knowledge, innovation, governance, and social ties. Methods used to collect data and the research sample are described in the research methodology section. In the research findings and results section, we present our findings and the main results, highlighting the results from the Knowledge and Innovation dimensions. Discussion of results follows, where we analyze the findings in light of collaborative practices and business pressures in the insurance sector. The conclusion section presents a synthesis of the research, as well as key takeaways and the implications for insurance managers and stakeholders. Implications of the study are projected to business partnerships and collaborative working environments.

Literature Review

Business networks have been studied from different perspectives and theoretical backgrounds (Dusyters, Heimeriks, & Jurriëns, 2003). The paradigm of transaction cost economics has been complemented with a more dynamic view where the opportunity to learn from others and the role of trust to increase the economic output of networks are paramount. We followed a collaborative perspective of business partnerships where learning, trust and innovation are at the center of the value creation process, highlighting relational and behavioral capabilities (Nooteboom, 2006).

Innovation and Competitiveness in Business Networks

Innovation is a dominant concept in business strategy. Only enterprises that are able to foresee competitiveness as a moving target and that are able to adapt to change will survive. On one hand, considering the rivalry prevailing in mature economic activities, innovation emerges as a source of sustainable competitive advantage. On the other hand, collaboration and innovation are closely linked to an open business environment and in a connected society. Innovation output is limited by internal competences, dominant logic and cultural filters (Choo, 2002). The critical success factors therefore involve external exploration and collaboration with peers, towards idea generation and novelty (Saebi & Foss, 2015). Furthermore, business relationships could be seen as inputs to innovation, learning, and the development of specialized products (Gulati, 1998).

Knowledge and Collaboration in Business Networks

Innovation is a strategic imperative and business networks are configurations aligned with the demanding context of a knowledge-based competition. As stated previously, business networks may facilitate interactions where economic actors share complementary knowledge and gather their unique competences (Blomqvist & Levy, 2006). Knowledge creation is needed to breed innovative ideas and agents´ diversity associated with novelty (Otto & Richardson, 2004). Therefore, collaboration in business networks could connect the dots by having external entities with different cultures and visions effect market opportunities. Innovation and idea generation are subject to an optimal cognitive distance (Nooteboom, 2006). In order to be engaged in creative dialogues, partner´s should be able to communicate and share the same meanings. Learning by interacting produces innovation but needs knowledge exchange, mutual understanding and dialogues. Therefore, the social dimension emerges as one of the most critical aspects. Balancing the partner´s diversity with their cognitive alignment is key to knowledge creation. The positive effect of social and cognitive dimensions in networks is aligned with knowledge management theories. Nonaka and Takeuchi (1995) identified the importance of common values, goals and trustful relationships. Coordination of partners based on trust is critical for knowledge creation as it supports the right social context of "Ba" (Nonaka & Kono, 1998). There is also a need for social ties to promote a favorable psychological context (Magalhães, 2006). On one hand, the partner's cognitive diversity, managed by the "strength of weak ties" will contribute to the dynamic generation of new ideas. On the other hand, cognitive proximity, managed by the "strength of strong ties" is needed so positive interactions can produce innovative ideas (Granovetter, 1983). Social ties, either weak or strong, are instrumental and should be aligned with the innovation level that is required.

Insurance Business – Nature and Specific Issues

Considering the nature of the insurance business, external quality attributes of insurance products should be stressed as a contributor to an excellent customer experience and trustful brand awareness. Competitiveness of insurance companies is linked with the quality of service of business partners that are in the front line of customer management. The nature of insurance products also stresses the importance of trust, namely when we consider the inverted economic cycle of insurance. For example, it is very hard to know, upfront, the precise figure of product profitability. Product pricing is calculated based on statistical analysis and given certain types of conditions. If risk assessment conducted by partners, is not rigorous and assumes other conditions, claims frequency may be above the technical break-even of the product. Therefore, risk assessment and negotiation, followed by underwriting processes, points out the dominant role of partners in value creation and profitability. The focus is set upon the importance of tacit knowledge in insurance as social interactions among partners and clients are crucial. The human factor and trust cannot be neglected in the insurance value chain, concerning customer relationship, risk analysis and service management. With proper attention, the product life cycle will be shortened (Carvalho, 2002) and product complexity will rise. Innovation associated with value added services will, incrementally, differentiate value propositions.

The role of Knowledge and Innovation in the Insurance Sector

Insurance companies are facing strategic challenges, namely a fast-changing business environment, new legal requirements, social and demographics pressures, new technologies and clients with more bargaining power. In a world with less information asymmetries, the threat of new entrants with low cost value propositions is raising. Therefore, positive technical results from operations (combined ratio < 100%, which is a measure of profitability) are proved to be difficult to capture. Insurance companies should differentiate themselves and explore service quality, trust and business relationships, in order to escape value destruction and strategies exclusively centered in price comparisons. That implies new capabilities and an innovation-oriented vision, aimed at a superior service and the development of specialized insurance products (Silveira, 2008). In this context, value creation is anchored in the development of internal competences, access to external specialized resources, agility, operational flexibility and service innovation (Carvalho, 2002). Collaboration with business partners is important to service innovation, learning and development of competences. However, how could it be possible to transform partner´s specific knowledge to value? Is the partners´ innovation potential already being explored in insurance networks?

Objectives and Model of Analysis

This study focuses on the collaborative system of the Portuguese insurance sector, including the network space where companies, insurance agents, suppliers, clients, service providers, etc. are linked in order to offer high-valued services. In a highly competitive environment the motivation should be in the development of internal competences, access to external specialized resources, operational flexibility and service innovation. These strategic elements can be fulfilled through interactions with other economic agents, i.e., through the collaboration between peers. Therefore, our approach underlines innovation, learning and service management. We follow a new mental framework that moves from productivity to relationships (Castells, 2002), requiring a certain level of disruption. The analysis of business relationships as a competitive domain was applied to the insurance sector essentially for three reasons:

(1) Historically, the insurance business always considered the development of business partnerships. So, insurance companies can be conceptualized as a big *hub of relationships*, making business connections among a full array of external organizations.

(2) The insurance industry has a pivotal role in the Portuguese economy. In 2013, this industry represented 7.9% of the country´s GDP and assets under management represented almost 32% of the GDP; it is an activity with a crucial role in the economy and the consolidation of the social and economic progress.
(3) Insurance is an information and knowledge-intensive activity (Porter & Millar, 85). The alignment between information and business is absolutely crucial to the exploration of partnerships and their relationship to the knowledge view, taking into account innovation, trust and client-driven orientation. (Leiria, 2013; Silveira, 2008).

As this industry is knowledge dependent, the nature of business relationships should play a leading role in contributing to a knowledge-oriented approach as a pre-condition to innovation and quality of service. In the specific case of networks in the insurance industry, the challenge is to gain more operational efficiency and a more effective relationship, addressing the competitive pressures of a Buyer´s market. The main objective is to obtain a differentiation strategy from knowledge and relationships. In this context the following management propositions/challenges were identified:

- How to explore Knowledge and Innovation in business networks, towards value creation?
- How to stretch the potential of knowledge and innovation outputs from partners?

Model of Analysis

The conceptualization of the collaborative system of insurance, covering heterogeneous partners along the value chain, suggests a holistic view. Our model of analysis highlighted *hard* and *soft* domains (See Table 1), where Knowledge and Innovation have a crucial role to explore business networks.

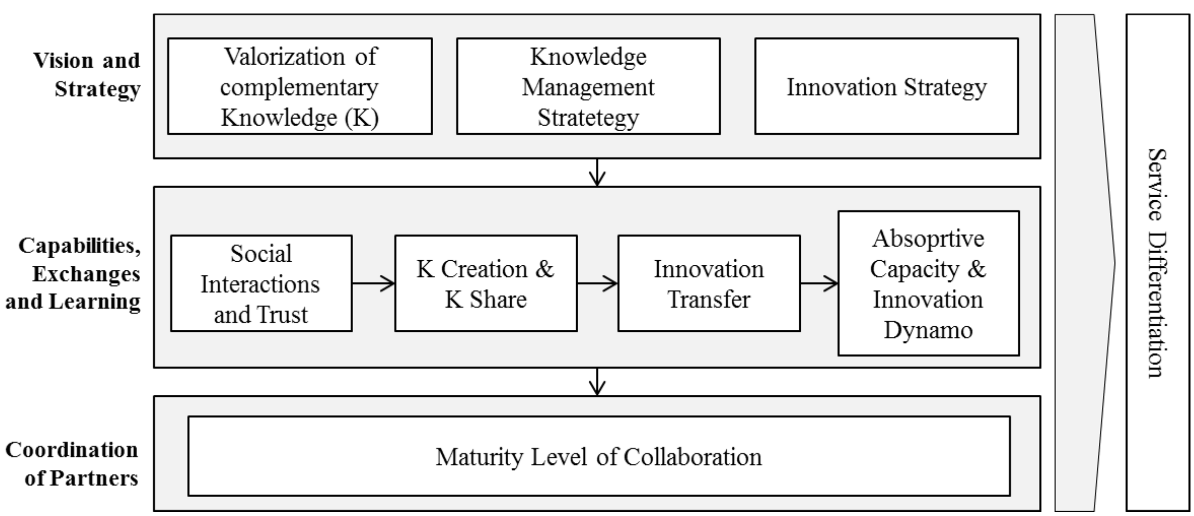


Figure 1. Knowledge and Innovation operational concepts in collaborative networks

In this paper, we focus only on a learning and innovation view to exploit the potential of business networks, namely in the insurance sector. The holistic view of collaborative networks that is briefly mentioned above will just set the scene for the development of this paper. It is possible to visualize the dimensions of Knowledge and Innovation and their relation resulting in the maturity level of collaborative working practices, as described in Figure 1.

Table 1. Dimensions of the overall model of analysis and references (brief)

Dimensions	Theoretical references	Brief Description
Structure	Transaction Cost Economics (TCE)	Structure influences governance types, knowledge acquisition and the degree of collaboration.
"Background"	Relational View	Capability to select partners with a wide array of criteria considering "organizational fit".
Formal Governance	TCE	Infrastructure, formal coordination and procedures are the basis for an efficient interaction.
Social Governance	Relational View	Socialization and mutual understanding are preconditions towards knowledge creation.
Knowledge Management	Knowledge Management	Access to external sources; capacity to internalize knowledge. Knowledge as a resource rooted in social relations. Absorptive capacity role in networks.
Innovation	Knowledge and Relational View	Innovation in the light of DUI Model (OCDE, 2008) stressing the role of stakeholders and deeply integrating external partners in innovation processes.
Information Systems (IS)	Socio-Technical Approach	Cost-effective infrastructure supporting the connectivity between heterogeneous systems.
Dynamic Capabilities	Dynamic Capabilities	Flexibility and organizational qualities towards collaboration. Continuous learning catalysts.
Execution	Relational View	Experience, roles and responsibilities.
Outcomes	Relational View	Performance following Balance Scorecard's four perspectives.

Propositions of the Study Focusing on Knowledge and Innovation

As mentioned above our focus was on the insurance sector as a real life occurrence of business partnerships where the challenge of creation value and service differentiation implies collaboration, learning, and innovation between interrelated partners. Considering the insurance collaborative system in Table 2 we present the specific propositions of the study having in mind the Knowledge and Innovation dimensions.

Table 2. Propositions of the study focusing on Knowledge and Innovation

Vision and Strategy
P#1: Inter-organizational knowledge is a source of competitive advantage in the insurance sector.
P#2: Knowledge creation should be one of the goals in partnership and innovation should be also a dimension to be managed.
Capabilities, Exchanges and Learning
P#3: There is a context that favors collaboration and social interaction with business partners, towards the goal of knowledge creation.
P#4: Current maturity level of insurance networks already supports the exploration of knowledge and values the Innovation role of business partners.
Coordination of Partners towards service differentiation
P#5: Future partnerships would be more knowledge-based and innovation is expected as an output of networks.

Research Methodology

The research method was based on the following steps: (1) Conceptual desk research and (2) Field research, namely with the validation of conceptual relations through field-work. In this exploratory study, 20 questionnaires were collected and 13 face-to-face complementary interviews were conducted. The main steps were: 1) Validate the survey with key experts from the insurance sector; 2) Survey with closed-end questions and 3) Interviews to deepen insights. Considering the research sample, immediate extrapolation of the data cannot be done in a definitive manner. However, insurance managers involved represent approximately 74% of the "Non-Life" portfolio and over 50% of the "Life" portfolio. Regarding the survey, each dimension of the proposed model of analysis was translated into questions (& metrics) of the inquiry. The answers were collected considering a maturity scale, as shown below, giving us a picture of the current collaborative practices in this industry. Figure 2 represents the scale used.

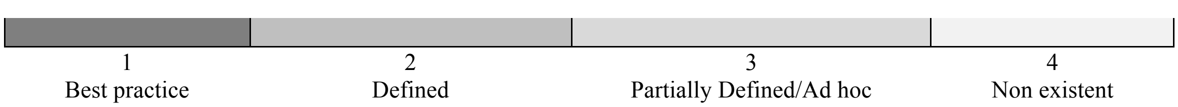


Figure 2. Scale of levels of maturity

CMMI levels were adapted to collaborative business practices (IT Governance Institute, 2007; Smith, 2012) with the following meaning:

- Best practice: defined process, measured, optimized and reviewed;
- Defined: normalized process with key metrics associated (KPI);

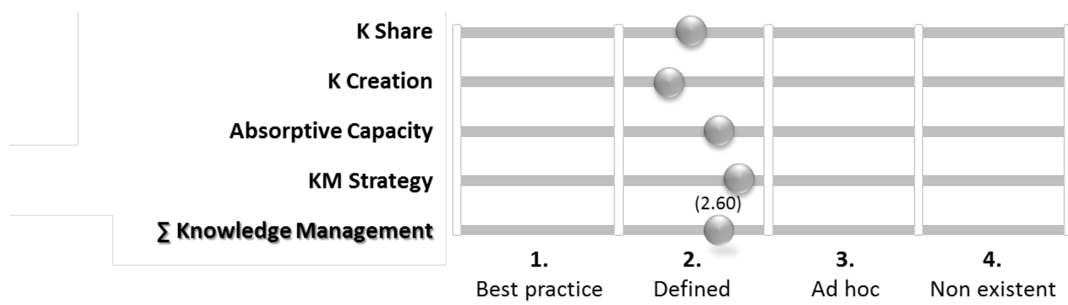
- Partially Defined/Ad hoc: the process is executed without KPI and it is not generalized.
- Non-existent: the process is not executed.

Results and Findings

In this section, we only show the results of Knowledge and Innovation maturity levels as they are paramount to the enhancement of service differentiation.

Knowledge Management (KM) Dimension – Results

Figure 3 visualizes the overall maturity of KM is "2,6". Processes are executed but showing performances sometimes near the low level of "Ad-hoc" maturity.



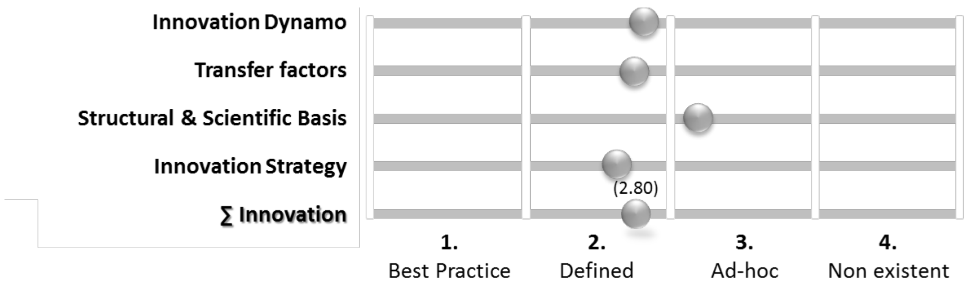
Topics	Value
KM Strategy	2,7
Absorptive capacity	2,6
K creation	2,4
K Sharing	2,5

Figure 3. Knowledge Management (KM) overall maturity

The detailed data analysis shows us that the "Absorptive Capacity", with an overall maturity of "2,62" is explained by different elements. "Relationship with the external environment", meaning access to external sources of knowledge, has a maturity of "2,6"; "Adequacy of external sources" has a maturity of "2,4" showing a reasonable and positive cognitive distance between economic agents in the insurance sector; "Transfer of Knowledge" has a low maturity level of "2,8" showing resistance in the internalization of new knowledge and a lower operational focus. Although there surfaced a relative positive maturity of knowledge creation and sharing, the low level of absorptive capacity does not allow an exploration of the value of business partners. Moreover, there is not a strategy for KM assumed. Knowledge processes are currently dependable only in individuals, without the ability to develop this dimension. Identification of obstacles for KM, another section of the survey, stresses an insufficient strategy and alignment of expectations between partners. Low socialization and trust are indicated as obstacles. On the other hand complementary knowledge of partners is not seen as an obstacle.

Innovation Dimension – Results

Figure 4 shows that the overall maturity of Innovation is "2,8" closed to an "Ad-hoc" level, reflecting a not yet consolidated business practice.



Topics	Value
Innovation dynamo	2,76
Transfer and diffusion factors	2,75
Structural and scientific basis	3,19
Innovation strategy	2,6

Figure 4. Innovation overall maturity

Access to innovation centers and scientific entities has the lowest maturity value. On the other hand, innovation dynamics also is blocked by the internal network i.e. resistance tof change. Outbound flows that could generate new ideas and transfer practices present low maturity levels.

Discussion

KM and Innovation are part of the big picture of the insurance collaborative system. Based on the surveys and the insights from the interviews, it was possible to relate the overall collaborative maturity level with the strategic issues of the sector. Figure 5 presents the maturity levels, followed by five key findings.

1. The global maturity level of collaborative practices is currently at an intermediate maturity point (2.56). It could be in the path towards Best Practices or also could slip to a lower degree.
2. Insurance collaborative networks seem to be more economic-intensive (economic factors are more valued) rather than knowledge-driven (innovation and collective learning are less observed). This reflects a more transactional approach rather than a collaborative network.

3. The current coordination methods are limiting the potential of partnerships as social governance is neglected - socialization is a pre-condition for learning.
4. There is a strategic gap regarding the as-is model of collaboration in the sector. The objective of incremental innovation suggests *Strength of Strong Ties* as model of interaction. However, *Weak Ties* seem to be dominant among partners.
5. Alongside the gap regarding external openness and social ties, endogenous factors should be improved as they affect internal network conditions and the external network outcome.

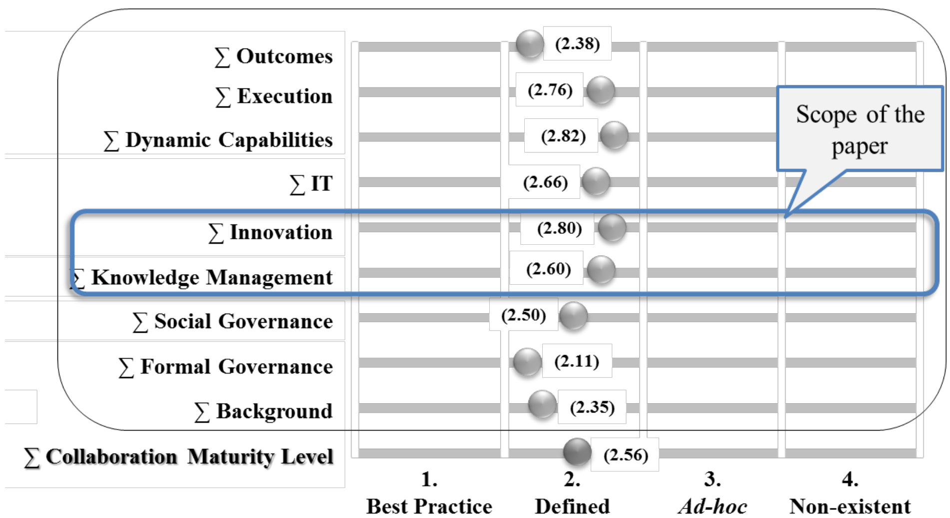


Figure 5. Overall maturity levels of insurance collaborative system

Key Challenges in Knowledge Management (KM) and Innovation

Insights from the study allow us to stress the main challenges regarding collaborative outcomes:

Challenge #1: There is a need to change the as-is coordination method. Socialization is a pre-condition to learning and should be managed as a part of a defined KM strategy.

Challenge #2: The insurance sector should highlight external openness, relations with scientific and research entities. The culture of collaboration should be nurtured.

Challenge #3: Current innovation roadblocks justify a paradigm shift. Insufficient absorptive capacity is conditioning innovative outputs from partnerships.

Challenge #4: Complementary knowledge from partners is recognized. There is a huge opportunity to be explored. However, to capture the potential value of relationships, a new social strategy is required, much more based on the “strength of strong ties”.

Challenge #5: Insurance transformation based on collaborative innovation requires also the internalization of knowledge. Leadership should create a positive anxiety towards change.

Concluding, we are able to validate our initial propositions as shown in Table 2.

Table 2. Validation of initial propositions

Proposition (summary)	**Conclusion**	**Results**
Vision and Strategy P#1 Knowledge and Innovation are sources of competitive advantage	☝ *Opportunity*	Innovation is a strategic imperative for the insurance sector.
P#2 Knowledge and Innovation are objectives in Insurance Partnerships	☟ *Strategic Gap*	There is a strategic gap. As-is coordination is based on strength of weak ties not aligned with business goals
Capabilities, Exchanges & Learning P#3 There is a context in favor of collaboration and social interaction.	☞ *Potential not explored*	Current collaborative networks are more economic-intensive than knowledge-driven.
P#4 Current maturity level supports Knowledge and Innovation.	☟ *Not yet confirmed*	Maturity of *soft* dimensions are low. Gaps are sustaining the power of networks.
Partnerships vs. service differentiation P#5 Future partnerships will be more Knowledge and Innovation-based	☞ *Value to be captured*	Innovation could be viewed as a dynamic process in which knowledge from partners could be gathered towards service differentiation.

Conclusion

In this exploratory study, we systematize challenges in managing partnerships in the insurance sector. As this industry is knowledge dependent, the nature of business relationships should concede a leading role to a knowledge-oriented approach as a pre-condition to innovation and quality of service. Collaborative relationships are instrumental to insurance competitiveness. Moreover, the tacit knowledge of partners is crucial to value activities directly linked with companies´ bottom line and reputation. Therefore, business relationships should be managed, highlighting the Knowledge and Innovation dimension. Currently, however, there is a strategic gap. Partnerships are being managed with an eye on efficiency and using a command-and-control coordination model. Formal dimensions are highlighted and partners are viewed only to achieve operational efficiency. Although the complementary knowledge of partners is valued, insufficient "strong ties" do not allow exploring that potential. Gaps in socialization, absorptive processes and internalization are sustaining the power of networks. Innovative outputs from partnerships are desired, although the right management model is not yet set up. A shift from productivity to strategic differentiation, based on Knowledge and Innovation is an opportunity in the insurance sector. Innovation could be viewed as a dynamic process in which knowledge is accumulated through learning and interactions with valuable partners. Therefore, a knowledge management strategy should be related with a social strategy. Learning from interactions, trust and social ties towards differentiation could be explored. Concluding, the major implications are that (a) Insurance players could explore the potential of Knowledge and Innovation in order to differentiate themselves; (b) Knowledge creation is preceded by social interactions that suggest the *strength of strong ties*; (c) partner´s engagement and social ties are critical enablers. From these takeaways we can say that it is imperative that a new way to coordinate business partners, much more focused on stronger ties, is recommended, in order to explore unique knowledge and innovative inputs in the insurance sector. For sure, insurance leaders will embrace collaboration and put Knowledge and Innovation in their management agendas. The development of research in the fields of Knowledge and Innovation in the context of partnership exploitation will enhance collaborative working.

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Use of process performance indicators as part of knowledge management in organizations

[Research-in-Progress]

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Abstract

The elaboration refers to the new approach of KPI tailored to the process approach to organizations management. Proposed Processes Performance Indicators are based on the life cycle of processes and involve the use of Information and Communication Tools in all its phases, from modeling to implementation and execution, and ending with their improvement. Within the phases mentioned analytical and control trend, will facilitate the ongoing control of process instances executed, and their operations, will also be implemented. It can be completed by visualization of processes and their instances using spatial tools. PPI is an important component of knowledge management in the organization. It requires intellectual contribution necessary to develop a complete business process models covering a coherent description of the algorithm of the process, the actors, the documentation, necessary resources and PPI. Full implementation of the process approach in organizations requires changing principles of thinking about the subject. It also requires a change in the perception of the principles of the organization. The effectiveness of the performance should be measured primarily according to the processes. The effectiveness of the organization is in this sense seen as a resultant of ongoing instances of processes.

Keywords: Processes performance indicators, key performance indicators, process management, life cycle of processes, information systems, geographic information system technology

Introduction

Process management is the increasingly used approach in various types of organizations. Implementation of the assisted approach is to increase the operational efficiency of the organization, and, at the same time, make it easier to adapt to the changing market conditions and to open wider opportunities for cooperation with other parties, including potential customers. Although modern implementation of the process approach does not have to be in accordance with such radical rules as reengineering, its use by evolutionary methods, also in the longer term, should lead to a complete transformation of the principles of functioning of the organization. Its implementation should support not only technological and organizational transformation, but should enable a whole new perspective on the effectiveness of the organization (Bitkowska, 2013).

This approach stems from the fact that more and more processes are executed in the environment of many organizations. In addition, the functioning of the organization affects more and more visitors (including owners, managers, employees, and customers whether state and local authorities), where the interests of individual groups are not always consistent with each other and with the interests of the organization (Freeman, 2002).

Based on the assumptions of Business Ethics, that the interest of the customer is the most important, and its satisfaction requires the cooperation of many entities. The question of process effectiveness, could become more important than the interests of individual organizations that will be involved in the implementation of each process instance. This follows from the assumption that the specific instances of business processes are sources of revenue. Bearing in mind that most of the tools used today for measuring the effectiveness (i.e. Balanced Scorecard, Scandia Navigator, EFQM framework, etc.) are aimed primarily at measuring the effects of the individual organizations, where the effects of the process are just one of the elements discussed methodology assumes that you develop tools to measure more precisely the effectiveness of the same business processes (Shafaei & Dabiri, 2008).

In this paper there is proposed a model for the use of process performance indicators (PPI) as part of knowledge management in organizations. It was assumed that one of the basic elements making up the knowledge of the organization are created in it, or used in business models. Therefore, the use of PPIs has been associated closely with business models and cycles of their lives. Develop business models and their application and enforcement is closely linked with the use of information and communication tools (ICT). The use of PPI requires the use of various ICTs: from process modeling tools through Web Technology, Enterprise Resources Planning / Business Intelligence (ERP / BI) and ending with spatial methodology, Geographic Information System technology (GIS). On the basis of spatial methodology can build a map of the organization are described in various areas (not only geographical, but above all heuristic and mathematical). This allows visualization PPI to use a special tool called herein maps organization.

While these considerations are theoretical in nature, studies have been subjected to the technical possibilities of implementation of the proposed model. Looking from a technical point of view, there is a possibility of using the proposed model.

The Need for Evolution of Performance Indicators in the Management Process

The use of Key Performance Indicators (KPI) was at one point one of the key factors to support the effective management of the enterprise. Generally KPIs are a system of indicators describing various elements of functioning of modern enterprises. Indicators describe different areas of functioning of the organization (Becker, Klingner, & Bottcher, 2011). They may have both strategic and tactical character. Ease of the use results from the fact that although there are quite a lot of KPIs (in fact it depends on the analysis and control needs of the management of the organization), they are relatively easy to calculate by using computer systems used to record events occurring within the organization (Wen, Chen, & Chen, 2008).

Striving to absorb the emerging opportunities in the market slowly begins to interfere with the desire to collect different types of resources. The essential question becomes the liquidity of the boundaries of the organization (Harrison & John, 1996). As a result, taking close cooperation with the customer into consideration, it can be proved that the satisfying of its needs can be engaging actors involved. This in turn means that different environments of individual organizations from communities' business processes start to differ which will include many entities. In this way, confusion may arise when determining what is more important: particular interest, individual organizations, or completion of successful instances of processes carried out by many entities.

For "organization" stand stakeholders interested in maintaining the status quo and the state with its fiscal policy. For "process" stand sources of revenue. Clients are interested in the product (service), and to a much less extent, the interests of the organization that delivers it to him. For organization with process approach the objective is to improve their efficiency through optimal servicing revenue sources. In this situation organization area for basic business processes can be expressed in the form of auxiliary processes, whose efficiency can be similarly calculated as the efficiency of basic processes. What is more, auxiliary processes should be included in the basic processes (usually as subroutine).

This approach changes the system of Performance Indicators. KPI, of course, can be developed further and used, among others, for internal reporting (e.g. for shareholders at the general meeting) and external (fiscal targets, statistical and other legal bonds). However, for process management new admissions can be assumed, in this study named Processes Performance Indicators (PPI), which can be used directly for process management.

Application of Process Performance Indicators in the Life Cycle of Processes

The use of PPI is closely related to the knowledge of the management of environment implementation processes. Defining PPI is associated with the construction, the implementation and the description of the activity of the organization, which is part .of the regulations and the corporate vocabulary, and above all. It is an important tool for supporting management processes.

The model of the use of PPI is based on the following assumptions:

- PPI is an element of modelling and business processes,
- they are based on the life cycle processes,
- they involve the use of various types of ICT,
- due to the multiplicity of processes carried out at the same time instance to visualization of the results, tools based on spatial technology i.e. the map organization can be used.

Genesis of the proposed PPI is based on the life cycle of processes. However, it is also assumed that virtually all phases of process life will be supported by ICT. PPI should appear on the stage of process modeling. That is why an important role in the development and subsequent use of PPI will play a variety of tools for business process modelling (BPMN, BPEL, RDF, etc.,) (Gawin & Marcinkowski, 2013; BPEL, 2016). The use of ICT has become, in this case, a prerequisite for the application of PPI.

Taking up the issue of process management depends on many factors. Some entities are fully geared to change the principles of operation, other organizations were somehow coerced (eg. through participation in business processes connecting multiple entities). Some organizations carry out a revolution by implementing a complete reengineering, others undertake designing and implementing processes selected by evolutionary techniques. An important factor to take such action may be to have the appropriate ICT that can promote or inhibit the implementation of the process approach. Aside from the specificities of the organization (or created for the purpose of the organization processes, alliances) it can be assumed that the life cycle of processes can be divided into the following phases (Weber, 2009).

1. Planning business processes
2. Process modeling
3. Implementation of business models and their conversion into process systems
4. Process execution
5. Verification and improvement of models
6. Quenching processes

Process planning can be seen as a preliminary stage. Its purpose is to define the actual and potential sources of revenue. Processes will be modeled according to the defined source of income. From this point of view the life cycle of process at this stage is important to identify the determinants of success for distinguished types of processes, and to indicate how they can induce their instances.

Designated types of processes are subjected to modeling. For process modeling, tools such as, ARIS, ADONIS or iGrafx can be used. The choice of tools to a large extent will determine the system used in the enterprise. The idea is that in the simplest way possible move the defined process models into IT system procedures. PPI should appear just at this stage of modeling. The condition is to provide a full version of the model, which should consist of the following elements (Jelonek & Stępniak, 2013):

- Process algorithm
- Actors
- Documentation
- Required resources
- PPI

The process algorithm includes operation system. The other elements of the description should be made adequately to the operation. This means that each operation will be assigned the type of actor and documentation which should describe the effects of its implementation, resource system, which is necessary for its implementation, and, the mentioned PPI. Model description should be consistent, although in practice it will require the use of several different types of schemes. It is important to use a dictionary to corporate semantic description of the operation, and all the elements that describe them, thus it is subjected to the rules of the description of the PPI as a part of the description of the operations (Dijkman, Dumas, & Ouyang, 2008). An additional requirement of consistency PPI is a matter of internal consistency of indicators. This means that the aggregated value of indicators describing the different operations cannot be contrary to the indicators describing the whole process or its subroutines.

The designed models should be presented in the form of electronic formalized and semantically consistent patterns stored in the selected notation. As mentioned, the notation should be consistent with the description of the tools of information processes used for modeling systems, such as e.g. UML. This allows trying to make the automatic conversion of the developed process models into the procedures of the used IT systems. Implementation and parameterization of the defined procedures should allow for modifications of corporate regulations in such a way that defined PPI became known to potential actors. On this basis, one can define rules of rewarding and punishing the actors for the realization of operations within specific instances of processes (Filipczyk, 2014).

For the process approach the most important phase is the process execution. Within its framework subsequent instances of processes and generated revenues are implemented. In this phase operational and tactical management of the implementation of the various instances of processes also takes place. The role of PPI is dominant in it. Due to the fact that each operation performed must be completed with the record of documentation, registering of the status of a process instance is regularly been made. In the documentation description, classification and assumed state of resources that should be involved in the implementation of the operation are used (Yongchareon & Liu, 2010). Data from the records are compared with the expected PPI, due to this date the status of implementation instance is currently determined, recently performed operation and current operational metrics are indicated. In extreme cases, negative operating values may cause interruption of the instance, in order not to generate further losses. With the PPI it is possible to be up to date with the assessment of the state of process instances, commitment and effectiveness of actors, strengths and weaknesses of ongoing types of processes. These analyzes can be done at any point of duration time of the process, not the calendar date.

The current results should be verified and conclusions should be used to improve process models. Generally it can be assumed that the positive conclusions of the analysis of the effects of specific types of processes should lead to the first phase - process modeling. Remodeled processes may be new versions of the process, which will replace the old ones or will be an alternative for them, depending on the state of the environment of the process.

Negative conclusions will lead to the extinction of processes. Typically, this will occur when the interest in the type of process decreases or PPI will be negative which will lead to too frequent interruption of process instance.

Construction of Process Performance Indicators

PPI are designed to support all levels of management, from operating through the tactical to the strategic one. In practice, this means that through PPI actors performing individual operations within the instances of processes can be controlled and it is possible to estimate the efficiency of the revenue source (del Rio-Ortega, Resinas, & Ruiz-Cortes, 2010).

Building a system of PPI one should adopt certain organizational and technological assumptions. The basic ones include:

- indicators can be attributed to the entire process or its individual operations,
- ratios should be predictable, so that the systems supporting the implementation of each process instance, were able to interpret the results recorded in documents and be able to take appropriate decisions,
- data processes are recorded on a regular basis immediately after each operation,
- an important issue is the ability to visualize the results for the currently ongoing process using spatial technology.

During the implementation of business process starting point is the executive procedure based on the algorithm of the process. According to the different notation it may be called differently, but in this discussion it is assumed that the algorithm is divided into operations. When designing algorithms processes should maintain the right detail. It is difficult to determine what detail is optimal. In these considerations it is adopted as a rule that any operation will define a document that must be created or supplemented immediately after the execution. Each operation can be attributed to various performance indicators. Generally, there are four types of the following indicators (Bitkowska, 2015):

- economical - relating, among others, to the issue of minimizing costs or revenue efficiency,
- time - for fast and efficient implementation of operations,
- quality - an indication of the quality requirements in relation to goods or services performed (at the level of operations – e.g. in conjunction with ISO standards),
- limit - this description of the situation in which it is necessary to interrupt or terminate a particular instance of the process.

PPI must be defined so that not only they determined what is measured, but their potential and expected value should be predicted as well. The value of the potential is an area of a field of the value that it can take. It can be used, among others, in formal verification calculated or charged of index value. The expected value determines, in turn, the desired value of the indicator. This can take values from a subset of the potential value and it identifies only those values that are desirable from the point of view of efficiency of the process.

By defining the expected values it can be determined whether the process instance is implemented in an effective manner. The condition of the efficiency test system of the processes is the necessity of recording data after each operation. These data are recorded in the documents assigned to individual operations (Schmiegelt, Xie, Schuller, & Behrend, 2013). Information systems supporting the implementation of individual instances of processes must be able to match the data stored in the documentation with the relevant indicators. Calculated values of indicators will be compared with their expected values. In this way on a regular basis, it is possible to control the state of implementation of many instances of processes simultaneously.

For large organizations, where at the same time many instances of processes are realized, standard analytical tools used e.g. in ERP systems or their extension of Business Intelligence (BI) will not always be able to keep the display of multiple data simultaneously (Ziora, 2015). As mentioned, PPI is a system of many parameters (the more types of processes are realized, the higher the number of indicators grows). They are diverse and they relate to many different values. Therefore, this paper proposes a solution other than BI systems. In this case, the proposed use of information systems based on GIS technology (Geographic Information System) – (Stępniak, 2015). However, the primary contribution of technology of these systems will be the possibility of defining abstract space and allocating different types of objects on them. This allows building maps of the organization. Maps of the organization can be a tool for visualization of the broad knowledge of the processes carried out in an entity.

Maps of Organizations as a Tool for Process Knowledge Management in the Organization

Maps of the organization are a tool for knowledge management. It will be the extension of the analytical tools used in the systems BI. There are many tools for data visualization, and the application of the spatial technology that allows for the visualization of the multiple objects simultaneously with multi-criteria (Mendeleev Table, 2016). Thanks to visualization, they can present both systems of all types of the designed processes, as well as the current states of the implementation of individual instances of them. With maps one can visualize the status of multiple instances of processes simultaneously. Not only through the use of synthetic indicators it is possible to visualize analytical control data.

Maps of the organization are a part of the model of the application of the PPI. Mentioned maps allow for the multi-criteria visualization of the PPI calculated on the basis of records the effects of operations instances of business processes. The functioning of the maps is based on the following components:

- complete descriptions of business process models, which take into account PPI, which are described using formal tools,

- system of current data recording made by information systems supporting the implementation of processes,
- analysis and control systems allowing for the processing of source data and comparing them with PPI and the interpretation of results,
- module of visualization.

The functioning of the presented tool depends on the cooperation of all four elements. Its operation can be divided into the following three phases:

1. Conceptual phase
2. Phase of data collection
3. Analytical-control phase

In the conceptual phase business process models and the space organization are defined. The use of formalized electronic tools for modeling processes to ensure consistency of models (including the description of all the elements) and the relatively simple conversion models in the process of information systems (usually ERP, can be CRM, CAD/CAM, and others). The visualization module is based on GIS technology. The starting point is the development of abstract space, where organizational unit (potential actors) will be applied. In turn, actors' system links resulting from the process flowcharts will be applied. That is why constant position of the individual units on the map is important. If information systems (ERP) have a description of the location of the organization's resources, the individual units are still able to have the appropriate resources assigned. It may also be used in process visualization. In the conceptual phase the issue of integration of all used ICT and their parameterization is fell. Its effect is a tool prepared for operations.

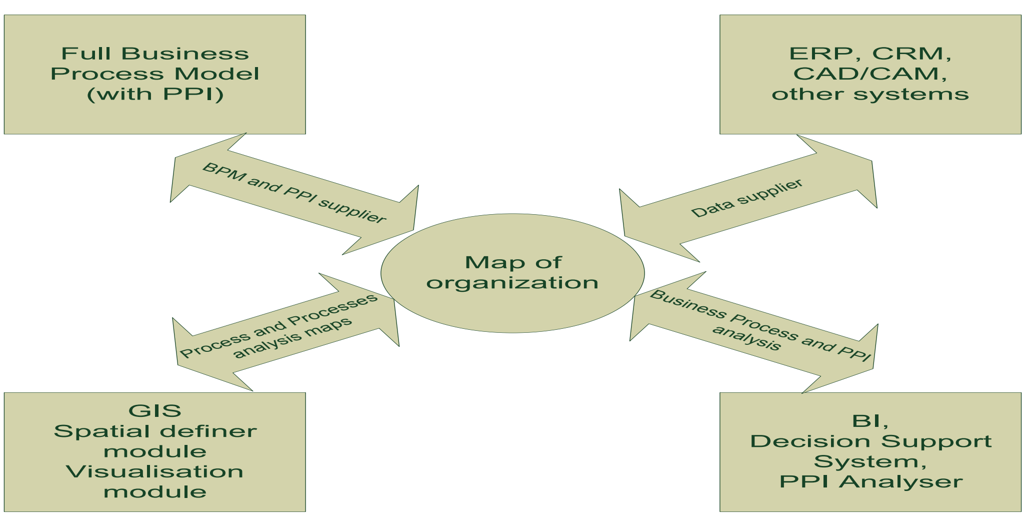

Figure 1: Diagram of functioning of organization maps

Data collection phase is associated with the current activities of the organization. With the procedures of information systems that support the implementation of individual process instances electronic documents are created. On this basis data about processes are collected. From the point of view of process management, the most important phase is analysis and control. All the elements of the model are used in it. Their participation shows Figure 1.

The basis of functioning of maps is the knowledge of processes (including their electronic models and PPI describing them) and data stored in computer systems (e.g. ERP) recording the implementation of each process instance. These data are subjected to the procedures and analytical control, and the results will be presented using the visualization module operating within the GIS (Karacapilidis, Tsiliki, & Tzagarakis, 2013).

The condition of the functioning of maps is the compatibility of PPI with data collected in the documentation describing the implementation of individual operations. Thanks to it, PPI Analyzer is able to determine whether the displayed values of the respective indicators take the expected values or not. The mechanism operates as follows:

1. Implementation of process operation.
2. Registration of documentation suitable for for the operation.
3. The assessment of the expected value of PPI for the operation.
4. Determination of the real values of PPI for the operation.
5. Comparison of the expected values to the real ones.
6. Visualization of the results.

Both the PPI Analyzer and Visualization module are multifunctional tools. They not only can make-to-date analysis of the status of individual instances of processes and visualize them. They can also analyze aggregated analyses according to specified criteria, such as e.g. the types of processes, instances, operations, actors, and other resources used (Viavattene, Scholes, Revitt, & Ellis, 2008). It is only important to have defined the appropriate data source. Visualization module may make a presentation map organization according to preset criteria based on data compiled by PPI Analyzer or directly from database systems (e.g. ERP), provided that it will have adequate procedures for data import.

The presented tool - a map of the organization - may be an important element used in knowledge management in the organization, describing the whole process issues. It can also facilitate fuller implementation of the process approach enabling process management in every phase of the process life. PPI is a key element in this model because it allows a more complete description of aspects of the process. It also allows defining measures by which one can evaluate the state of implementation processes.

Conclusion

The presented model is at the stage of being worked out. A theoretical model and functioning rudiments have been developed. Commercially available software that is necessary to implement the model has been analyzed. Attempts were made to cooperate with manufacturers of computer systems over implementation of the proposed solutions. However, the process is time consuming and further it requires some investment in the development of the software offered and the cooperation of several companies. The problem is that the preparation of the tools in the form of maps of the organization will not solve the whole issue of the application of the PPI. The application of the proposed model will require overcoming several more significant problems. So far, in practice the conversion of business process models for process systems still have not been completely resolved.

Problems can also occur at the stage of integration of various information systems with GIS, in fact with its spatial definer module when a question of rules of defining the organization space appears. Difficulties may also be provided by the need to preserve the semantic and substantive consistency of models, including PPI. A barrier to the use of this tool may also be the need to have adequate knowledge by its users, this applies to both process designers, and then their integrators and implementers. In spite of the difficulties mentioned above, the proposed tool can be an important element supporting the implementation of the process approach in organizations. With it, it is possible to perform ongoing supervision on the implementation of specific instances of processes, as well as on an ongoing basis to improve the processes and adept it to market requirement. At the same time, the discussed tool will complement the traditional organization management tools to provide comprehensive data on processes, which then can be transferred to the results obtained in the cross-section of the organization.

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Scientific and ethical implications of neuromorphic technology

[Research-in-Progress]

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Abstract

Neuromorphic technology is a significant advancement in medical technology, which paves the way for sweeping changes to the treatment certain disabilities, e.g. blindness or loss of limb. In addition to treating certain medical conditions, this same technology will most assuredly advance the robotics industry light years into the future. The terms 'neuro' and 'morph' that are defined as brain or nervous system, that changes from one thing into another by small and interconnected steps, respectively. Such definition appears to describe well the change from organic gray matter, into the silicon based microprocessors used to emulate the brain functions. As with any significant technological advancement, there are frequently as many issues as there are benefits, and neuromorphic technology is no different. There are concerns surrounding the inability of the developers to control artificial agents, which will continue to advance beyond the abilities of their human benefactors. There is also an ongoing ethical discussion within the international community surrounding the potential use of this technology and other technologies with similar cognitive abilities. Significant time and effort has been expended since 2002 to organize the international community, classify, and assemble the body of knowledge relating to machine ethics.

Keywords: emerging technology, neuromorphic, ethical, artificial agents, microprocessors, technology, robots, performance enhancements, prosthetics

Introduction

Neuromorphic technology is taking computing to the next level. Functionally equivalent to the human brain, which contains more than a billion neurons, processors like the International Business Machines (IBM) True North chip have grown to contain in excess of a million neurons. It will provide considerably more computing power in a smaller, more energy efficient package ushering in the next generation of intelligent computing. Computers will be faster and demonstrate more advanced cognitive functions than their predecessors; however, with cognition comes responsibility. The artificial agent as defined by Johnson (2015) is a "computational device that performs tasks on behalf of humans and does so without immediate, direct human control or intervention" (p. 708). The artificial agent can be non-complex like the bots that automate Internet searches or as intricate as a robot that is designed specifically for personal use, providing personal service and protection for its owner (Johnson, 2015). Additionally, micro-processors, currently in development are changing the way the medical community reacts to prosthetics or visual defects. These changes are having a profound effect on human anatomy by providing visual acuity where none previously existed and potentially enhancing normal performance (Rosahl, 2007). The advances are bringing into question ethical dilemmas never before encountered. Do we limit their ability to function on their own? Do we provide limits or fail safe programming to prevent them from violating certain moral or ethical norms? Since morality and ethics are personal and situational, who determines what limits, if any, should be placed within its programming? In order to advance beyond the current discussion, research must first be conducted to evaluate the need for further exploration of the ethical and cultural issues associate with acceptance (Board, 2008).

Literature Review

While some may argue the ethical dilemma created by the advent of artificial intelligence or other advanced technology with cognitive functions is relatively new as early as 1942, Asimov authored the now famous Asimov's Laws of Robotics in his fiction based work, *Runaround* (Kernaghan, 2014).

1. First Law: A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. Second Law: A robot must obey orders given to it by human beings except where such orders would conflict with the First Law.
3. Third Law: A robot must protect its own existence as long as such protection does not conflict with either the First or Second Law (Kernaghan, 2014).

Kernaghan (2014) noted that artificial intelligence has grown at an unprecedented rate and the future envisioned by Asimov in the 1940's is quickly becoming a reality. Conversely, the current military application of artificial intelligence invokes an irreconcilable paradox, invalidating Asimov's Laws. A 2011 United Kingdom (UK) Engineering and Physical Sciences Research Council and the Arts and Humanities Research Council composed the following code of ethics to better address the artificial agent's development;

1. Robots should not be designed solely or primarily to kill or harm humans,
2. Humans, not robots, are responsible agents
3. Robots are tools designed to achieve human goals,
4. Robots should be designed in ways that assure their safety and security,
5. Robots are artifacts; they should not be designed to exploit vulnerable users by evoking an emotional response or dependency,
6. It should always be possible to tell a robot from a human (p. 500).

Renewed emphasis on the debate can be directly attributed to recent developments in neuromorphic technology. Now more than ever, humanity is faced with the prospect of personal interaction with artificial agents and cybernetic individuals, dependent on prosthetic devices attached or implanted to correct anthropological frailties (Kernaghan, 2014). Boahen (2005) says "[that neuromorphic microchips are] compact, efficient electronics based on the brain's neural system [that] could yield implantable silicon retinas to restore vision, as well as robotic eyes and other smart sensors" (p. 56). The silicon design of the microchip allows it to share the same physics as the neurons it is emulating, rendering a near perfect imitation of the nervous system (Liu & Delbruck, 2010). Neuromorphic technology is rapidly expanding the medical field, allowing the doctor to correct medical trauma or birth defects in a way never before conceived. Prosthetics are no longer limited to external extremities. For instance, neuromorphic technology is spawning research into silicon "retinas" that will one day provide sight to the blind and potentially enhance the vision of those with no known abnormalities (Rosahl, 2007).

In addition to the treatment and prevention of neural abnormalities, the aforementioned technology has the potential to provide otherwise healthy people with enhanced performance. Creating a hybrid human known in science fiction circles as a cyborg. It is this enhanced performance via surgically implanted devices that will bring about the renewed discussion of ethics (Rosahl, 2007). According to Johnson (2014), some argued that because certain artificial agents learn as they operate, those who designed or deployed those agents may not be able to control or even predict what their agents will do. As these agents become increasingly more autonomous, the argument goes, no humans will be responsible for their behavior. Conversely, the case has also been made that not only should humans be held responsible, but more specifically the design engineer accredited with the creation of the artificial agent should be held accountable on the grounds of professional responsibility (Johnson, 2014). The concern as presented by Yampolskiy and Fox (2013) is the general consensus seems to be that no set of rules can ever capture every possible situation and that interaction of rules may lead to unforeseen circumstances and undetectable loopholes leading to devastating consequences for the humanity.

Other than the obvious physical differences, there are structural differences worth noting. According to Liu and Delbruck (2010), the neuromorphic sensors are designed and implemented using man made circuit boards in a two-dimensional (2D) space, while the cerebral neuron that it is emulating was created by nature in a three-dimensional (3D) space. The disadvantage afforded the sensor is overcome by the speed of the electronic circuit, which is more than a factor of 10^7 faster than the neuron it is emulating. According to Boahen (2005), the brain does not execute coded instructions; instead it activates links, or synapses, between neurons. Each such activation is equivalent to executing a digital instruction, so one can compare how many connections a brain activates every second with the number of instructions a computer executes during the same time. Synaptic activity is staggering: 10 quadrillion (10^16) neural connections a second. It would take a million Intel Pentium powered computers to match that rate plus a few hundred megawatts to juice them up. In addition to general construction and speed, retinas designed using silicon has shown an increased (>10^5) performance in illumination and sampling rate improvements in the kilohertz range (Liu & Delbruck, 2010).

The neuromorphic chip design is not without its problems. The body's cellular construct is capable of continuously adjusting its operating parameters to its changing environment. This is currently not possible with the existing silicon chip designs (Liu & Delbruck, 2010). Nearly all neural implants involve an invasive surgical procedure that is not without risk. The most significant risk to the patient is an unpredictable response from the electrical stimulation of the neural pathways. In some cases, relatives and friends have noticed changes in the patient's personality (e.g., transient confusion, slowness of thought, euphoria or depression) although the patients are often satisfied with their treatment. It is not evident, however, based on Rosahl (2007)'s medical experience, if these changes are a result of the treatment or an unmasking of other previously unobserved problems. In order to avoid these issues Yampolskiy and Fox (2013), believed for brain-inspired artificial intelligences, the focus will be on preserving the essential humanity of their values, without allowing moral corruption or technical hardware and software corruption to change them for the worse.

Advances in technology are often accompanied by unintended negative consequences brought about by the distortion of the intended purpose. Drones, stem cell research, organ harvesting, fission, and fusion all began with a much nobler purpose in mind. Neuromorphic technology will not be immune; Rosahl (2007) suggested that there is a potential for abuse and there is a need for further ethical analysis. To many, enhancement by connecting electronic devices to the human body and brain will appear, at least prima facie, morally suspect (Rosahl, 2007). According to Sandberg (2014), developing brain emulation is going to require the use of animals. They would be necessary not only for direct scanning into emulations, but in various experiments gathering the necessary understanding of neuroscience, testing scanning modalities and comparing the real and simulated animals. This perspective will only intensify the discussion of the moral and ethical issues surrounding the development and employment of neuromorphic technology (Sandberg, 2014). In order to better prepare the public for the advent of artificial agents in their midst, increase acceptance, and decrease potential fears, it is necessary to understand participants' most basic response to the ethical dilemmas through a detailed study of their reaction to the survey questions.

Proposed Methods

Limited research currently exists on the ethical questions surrounding the use of artificial intelligence as it relates to; artificial agents in the home, computer chips implanted in the brain to enhance visual acuity, or as part of the control mechanisms used in prosthetic limbs. Rosahl (2007) discusses the ethical considerations as they relate to the use of this technology to enhance human performance beyond what is considered normal. His research was limited to the discussion of the ethical use of neuromorphic technology to enhance normal human performance and the risk of the adverse effects to the individual and society (Rosahl, 2007).

Research Questions

RQ1: What differences exist between those with a Bachelor's degree or higher as opposed to those with lower education levels?

RQ2: What factors correlate with a positive view of artificial agents toward quality of life?

RQ3: Is income useful in predicting opinions of artificial agents as ethical?

RQ4: Does religiosity play a role in the determination that artificial agents are unethical?

Hypothesis

H_0 -> The majority of respondents consider the use of artificial agents for quality of life improvements (vision or prosthetics) and personal services ethical.

Participants

Based on the research bias of the social network of the researcher the majority of participants are expected to be college educated, 25 – 65 years old, with an annual income exceeding from $35,000 – 100,000 per annum. The participants will be comfortable with technology, using Facebook and/or LinkedIn on a regular basis. It is expected that the gender mix will be evenly split between male and female, and most will identify themselves as religious, attending services regularly. Again, this dataset is a direct result of using the researchers demographic on LinkedIn and Facebook.

Research Design

A quantitative method will be used to draw generalizations about the participant population determining whether a relationship existing between the variables and the opinions on the ethical implications of the implementation and inclusion of artificial intelligence into the lives of the general public. The questions will be closed-ended questions with six independent variables; education, age, gender, income, and two questions on religiosity. The dependent variables consist of two questions that will endeavor to establish the participant's views on the ethical ramifications of utilizing electronic implants for quality of life improvements, specifically vision and prosthetic limbs, and the use of artificial agents as personal assistants (e.g., servants, butlers, babysitters). This instrument was chosen based on the ease and speed of implementation and the ability to collect sufficient data necessary to garner support for further study. Additionally, quantitative research, according to the post-positivism, is the most appropriate method when studying humans and human interaction. Creswell (2007) described post-poitivism as challenging the traditional notion of the absolute truth of knowledge and recognizing that we cannot be positive about our claims of knowledgewhen studying the the behavior and actions of humans.

Instrumentation

A hybrid of demographic and religiosity questions were taken from multiple surveys and re-designed for this survey. The questionnaire was designed with simplicity in mind and therefore repeatable to better ensure data reliability see (Appendix A). Data validity is dependent on the sample size, which may be insufficient during the initial assessment. Bowerman, O'Connell, Murphree, Orris, Huchendorf, Porter, and Schur (2012) stated that the response rate is the proportion of all people whom the researchers attempt to contact, that actually respond to a survey. A low response rate can destroy the validity of a survey's results (p. 294). In the case of this survey, the sample size is limited to the number of people available in the researcher's contact lists, but is expected to be sufficient.

Procedure

The instrument will be presented via social media (e.g. LinkedIn & Facebook) to obtain the maximum participation possible given the timeframe allotted for data collection, which currently is limited to the time remaining in this class. The questionnaire is strictly voluntary with no funding allocated for participant compensation and intended to be completed individually. Informed consent and assent will be implied. A complete description of the survey and its purpose will be provided for the participant to read prior to answering the questionnaire.

Data Analysis Plan

Trochim (2006) stated that descriptive statistics simply describe what is or what the data shows. The use of descriptive statistics will be utilized to determine what the data stays overall providing a simplistic description to the data. The use of both one-way and two-way analysis of variance (ANOVA) with an F-test and Chi-Square with the Degrees of Freedom (df) will be used to analyze the data collected from the questionnaire. The Chi-Square allows a statistical inference to be made using the data as represented on the Chi-Square Distribution (Bowerman et al., 2012). According to Bowerman et al. (2012), one-way ANOVA is used to estimate and compare the means between two or more groups. The two-way ANOVA is utilized to analyze multiple variables using the sum of the squares. Data analysis will be performed using IBM's Statistical Package for the Social Sciences (SPSS).

Conclusion

The analysis is expected to show that there is a correlation between education and the use of artificial agents for quality of life improvements (vision or prosthetics) and personal services (RQ1). Conversely, no correlation between the generations or household income, (RQ2) and (RQ3) between education and the use of artificial agents for quality of life improvements (vision or prosthetics) and personal services is expected. The overall majority of respondents are expected to consider the use of artificial agents for quality of life improvements (vision or prosthetics) and personal services ethical.

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Jennifer Breese holds a Doctorate in Information Systems and Communications from Robert Morris University in Pittsburgh, Pennsylvania. Jennifer spent nearly 20 years in various sectors of the technology industry with much of that time rising through the ranks at FedEx; her last role was as a Senior Strategic Solutions Manger at the FedEx University. In 2011 she began teaching at various colleges and universities continuing in industry while publishing several articles on topics related to how technology changes social norms. In the fall 2015 she began to work full-time at Middle Georgia State University in Macon, Georgia as an Associate Professor of Information Technology.

Appendix A

Education completed

1. What is the highest level of education you have completed?

- ○ High School or Equivalent
- ○ Vocational/Technical School
- ○ Some College/Associates Degree
- ○ Bachelor's Degree
- ○ Master's Degree
- ○ Doctoral Degree or equivalent
- ○ Professional Degree (MD, JD, etc.)

Birth year

2. What year were you born?

- ○ 1928-1945
- ○ 1946-1964
- ○ 1965-1980
- ○ 1981-1997

Gender

3. What is your gender?

- ○ Male
- ○ Female

Income

4. What is your Current Household income?

- ○ Under $30,000
- ○ $30,000-$49,999
- ○ $50,000-$74,999
- ○ $75,000-$99,999
- ○ Over $100,000
- ○ Would rather not say

Technology: The use of Neuromorphic Technology (electronic systems) to control the nervous system is:

Rank the following 1-7 based on your opinion of the questions. With 1 being how you be most likely to answer the question.

- ○ Ethical in cases where the technology controls prosthetic limbs, the retina or assisting in other disabilities
- ○ I do not really know because the technology is not something I understand even remotely

- ○ Fine because it would be properly vetted by the health care community
- ○ Fine in most scenarios because the government will regulate the uses of the technology
- ○ Too dangerous as it could be controlled in warfare
- ○ A slippery slope to control other more advanced implant technologies
- ○ Feared based on my religious teachings and background

Religiosity

The following questions will be assessed using the Likert Scale and assigning the values 1-5 to Agree, Strongly Agree, Neutral Strongly Disagree, and Strongly Disagree (Bowerman, et al., 2012).

5. Do you consider yourself a religious person?

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

6. Do you regularly attend worship service?

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

7. Do you agree that the use of robotics/artificial intelligence for quality of life improvements (vision or prosthetics) is ethical?

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○

8. Do you agree that the use of artificial life forms for in-home personal service is ethical?

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
○	○	○	○	○