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Abstract

In this paper, an explanatory design theory for Financial Market Surveillance Systems is presented, which addresses both user requirements and regulatory demands. The identified general requirements and generated general components of the proposed design theory provides a theoretical foundation for design of implementation of highly flexible and real-time surveillance systems for capital markets.

Keywords: Financial Markets, Surveillance Systems, Explanatory Design Theory

1 Introduction

Information sources, such as financial blogs and tweets, seduce nonprofessional investors into investing in potentially suspicious financial instruments (SEC, 2012). Many investors struggle with their involvement in faulty investments. For the identification of market abuse, Information Systems (IS) for market surveillance include the detection of notable market abuse patterns in structured data (Eren & Ozsoylev, 2006). However, as of yet, there has been no research that integrates both structured and unstructured user-generated content with the information provided by the regulatory authority in a system that supports financial institutions in their surveillance tasks. The aim of the proposed design theory is to address this research gap by formulating design recommendations for an IS that supports market surveillance decision making.

The research presented in this paper is based on a three-year research project that provided the opportunity to develop an IT artefact to detect market manipulation. From October 2010 through September 2013, the market surveillance system was developed, implemented and evaluated in close researcher-practitioner collaboration ("Project FIRST," 2013). The domain experts and regulatory authorities intervened as needed to align the design theory with their surveillance issues.

This paper intends to contribute to the explanatory picture of market surveillance by providing insights into an explanatory design theory for financial markets as well as to support regulatory authority decision making by proposing a design solution for market surveillance. Thus, the study is led by the following research question: What are the general requirements and general components of financial market surveillance systems that are capable to detect market manipulation initiated via social media?

This paper is organized as follows: the next section provides a brief research background regarding market manipulation and design theories for IS, followed by proposed study design. Finally, a design theory is described, followed by a conclusion.

2 Research Background

2.1 Market Manipulation

Allen and Gale (1992) investigated different manipulation schemes, distinguishing between three groups of manipulation strategies. The first group consists of trade-based manipulations used as strategies for buying and selling that do not result in changes to beneficial interests or market risks. The second group is made up of information-based manipulation strategies, where false and misleading information is published in order to manipulate prices. The third group is made up of action-based manipulation strategies, in which compromising actions are undertaken by the management in order to affect the value of the company. Market manipulation related to the illegal disclosure of untrue information by the sender via unstructured data has been explored (van Bommel, 2003). The "pump and dump" market manipulation is one of the most widespread fraud schemes (Securities and Exchange Commission [SEC], 2012), manipulating share prices by first buying a specific stock and then spreading untrue positive information about the company in order to push share prices to an artificial level. The Internet (e.g., financial news platforms and blog forums) is used to spread the misleading information. Profit is then made by selling the stock at this artificial price level (Aggarwal & Wu, 2006). Affecting the share price of penny stock companies is therefore much easier than of large cap companies whose shares are traded by professional institutional investors. In summary, to detect the various types of market manipulation, a corresponding surveillance system needs to handle traditional data (e.g., time series) as well as the non-traditional data (e.g., news, blogs, and twitter platforms).

2.2 Design Theories for Information Systems

Several studies on theory-building approaches in Design Science Research (DSR) have been published in recent years. In (Hevner, March, Park, & Ram, 2004), seven guidelines were proposed to assist design science researchers in both contributing to IS theory and creating and evaluating as-of-yet unknown and innovative information technology (IT) artefacts. Particularly relevant to this study was the recently-developed

IS design theory proposed by Baskerville & Pries-Heje, (2010), which was an explanatory model of design IT artefacts. The theory distinguishes between general components and general requirements where the components are justified by the requirements. The explanatory design theory explains why a set of requirements is satisfied by a set of components. Hence, only two essential parts are needed for a complete explanatory design theory: general requirements and general solution components. Nevertheless, an evaluation with the domain experts and regulatory authority will be provided.

3 Study Design

3.1 Action Design Research

The general requirements and components of interest are identified and the action design research (ADR) methodology for design science research problems is utilized to merge science and practice (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). The method bridges the gap between research and practice (Baskerville & Myers, 2004) and is appropriate for collaborative projects between scientists and practitioners who wish to develop or improve solutions for real practical problems (Marshall, Willson, Salas, & McKay, 2010). Thus, ADR is appropriate for this project because it is expected to provide a solution to a real-world problem while reflecting on lessons learned (i.e., by formalizing the design theory).

ADR is by its nature an intervention, in this research, not in a unique organizational setting, but on the European regulatory background where financial authorities face the problem of market abuse and the need to counteract such abuses. In order to satisfy the reliability of this research the findings were steadily counterchecked with practitioner of the project consortium including stakeholders from a European financial supervisory authority. More precisely, during sequentially held consortium meetings, developed IT components where presented and the practitioner provided feedback if they provide a solution to the problem.

3.2 Research Stages

In our case, the ADR stages are maintained iteratively in cycles of theory and practice steps (Baskerville & Wood-Harper, 1996) and in close collaboration between the participants, leading to the generation of general requirements and general components that constitute an explanatory design theory. The ADR stages are detailed as follows (Sein et al., 2011):

Stage 1: Problem formulation
The project task is to develop an IT artefact to detect market manipulation. Thus, the main driver for development is the support of market surveillance tasks via systematic collection and analysis of any data that can be utilized for decision support. The project

involved other researchers and practitioners from both the financial and IT domains; the market surveillance project team consisted of 15 partners (five scientists from Slovenia, Spain, and Germany; two practitioners from the German and Italian regulatory authorities; and eight practitioners from Germany and Italy). The role of the researchers was to consider the problem in order to assess the situation from a scientific perspective and contribute accordingly to the knowledge base. The practitioners worked in a market surveillance context as financial domain experts.

Communication was maintained over a project-web service platform that contained all project-relevant documents (e.g. models, prototypes, documents). The platform was extensively used by both practitioners and researchers.

In this first stage of the project, user needs were identified and problem awareness for a specific goal was generated[1]. From a theoretical perspective, the literature steam on decision support systems (DSS) was examined, the initial questions to be discussed with regulatory authorities and practitioners were settled on, and possible methods were debated. The first meeting was set for this discussion.

Stage 2: Building, intervention, and evaluation (BIE)

In these process steps, collaboration between practitioners and scientists was motivated by specifying the activities that should lead to the desired solution for the problem. In doing so, the researchers initiated the first semi-structured interview, which included the following questions: What is to be accessed? What is the decision about? Who is the decision maker? Who is affected by the decision? In several further meetings and telephone conferences, the tacit knowledge regarding how to assess the market abuse driver was explored.

The data collected in collaborative meetings was analysed instantly within the team of practitioners, users, and scientists. In each meeting, the initial question served as both a starting point for discussions and a focus point for the resultant discussion on gaining a better understanding of market abuse. The attributes were used to enhance understanding of the phenomenon (Hadasch, Mueller, & Maedche, 2012).

Over the course of the project, the entire team met in person several times in annual meetings, each of which lasted three days. In these meetings, development stages were presented, possible improvements and ideas were suggested, and subsequent steps were discussed. The market surveillance team additionally met in person twice a year. In addition, several telephone conferences were conducted.

Initially, the system was designed as a prototype qualitative model (Alić, Siering, & Bohanec, 2013) allowing the derivation of initial design principles. The prototype was evaluated in two ways. First as a simulation where artificial data was utilized to simulate and prove the usability of the prototype and second as a verification of whether

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[1] FIRST Consortium D1.2 Use case requirements specification, http://www.project-first.eu/public_deliverables.

the model addressed the problem. In the subsequent phases, further developments were continuously made, discussed, and evaluated, resulting in a final IS.

Stage 3: Reflection and learning
This was the continuous stage, conducted synchronously with the two first stages. Across all three stages, possible problem solutions were re-conceptualized, ensuring greater generalizability of learning. During the entire project, the permanent involvement of a regulatory authority member and the evaluation phases resulted in the development of general requirements and general components.

Stage 4: Formalization of learning
The learning was incorporated into the outcome, representing a generalized solution to the problem (Sein et al., 2011). In this stage, nine general requirements and five general components were formulated as the design theory for a market surveillance system. Table 1 presents the summary of ADR cycles in the project.

ADR Stages and Principles		Outcome
Problem Formulation		
Principle 1: Practice-inspired research	The main driver for this research was the need to support market supervisory authorities in market surveillance tasks.	Recognition: Based on recognized shortcomings the IT Artefact should operate on: -structured time series data -unstructured user-generated content data -and information provided by the regulatory authority.
Principle 2: Theory-ingrained Artefact	General theoretical background related to model-driven DSS (Turban, Sharda, & Delen, 2010)	
Building, Intervention and Evaluation		
Principle 3: Reciprocal shaping	Infrastructure for the retrieval, storage and knowledge extraction from social network was expected to be an ongoing problem. The developed prototypes were steadily counterchecked with the regulatory authority.	The prototype was designed as a qualitative model.
Principle 4: Mutually influential roles	The role of the researchers was to assess the situation from a scientific perspective. They also acted as the artefact developers.	The prototype was iteratively developed and evaluated within

Principle 5: Authentic and concurrent evaluation	During the development, the artefact (i.e. the instantiated prototype) was continuously evaluated within the project team including the regulatory authority members. The final IS was evaluated by the potential end-users from financial institutions.	the team resulting in a final IS (Alić et al., 2013)
Reflection and learning		
Principle 6: Guided Emergence	Constant intervention and evaluation lead to re-conceptualization of possible design components.	Refined version of the design.
Formalization of learning		
Principle 7: Generalized outcomes	Formulation of financial market surveillance constituting explanatory design theory: interconnection between theory components and goals to apply the knowledge to the problem class.	A set of general requirements and general components.

Table 1. ADR Stages based on Sein et al. (2011)

4 An Explanatory Design Theory for Market Surveillance Decision Support

This section provides the general descriptions, units of analysis, and requirements in the construction of the desired system as the results of ADR stages. Further, it explains artefact classifications in order to greater conceptualize generalized components. The meaning of the word "requirements" as it is used by (Baskerville & Pries-Heje, 2010), refers to a "condition or capability needed by a user to solve a problem or achieve an objective."

4.1 General Requirements

Through meetings and telephone conferences with the experts, a set of general requirements was established. One of the practitioners pointed out that: "The target users are surveillance staff members who are employed by a regulatory authority." Other experts on the team highlighted the importance of daily observations: "The surveillance staff members need to prove daily if some bad guys are out there." As a consequence, the DSS focused on compliance staff members and their daily work activities in the context of market surveillance. DSR on DSS has shown that most systems are designed to support IS practitioners and managerial users as a single user (Arnott & Pervan, 2012). Focusing on classes of systems that support decision-making processes of regulatory authorities, compliance officers in financial institutions can be expected to benefit from market surveillance DSS. The importance of this research is

grounded on the nature of financial DSS and the consequences that such newly-introduced methodologies and artefacts can have upon its users. Hence, the general requirements of the system were assumed to be as follows:

The task: The market surveillance officers attempt to ensure the proper functioning of capital markets in accordance with the regulation rules (R1).

The decision support: The market surveillance officers are supported in their daily efforts to maintain observations of market participants' abusive behaviours (R2).

Compliance offices are not profitable cost centres (Cumming, 2008), so the user needs to ensure market surveillance is as time-efficient as possible in order to reduce costs. As a result, the following requirements are defined:

The signalling: If an anomaly occurs, an alert needs to be generated (R3).

The surveillance: Monitoring the market and the market's behaviour implies timely analysis of a large number of financial instruments (R4).

The data monitored is primarily structured (e.g., in a time series). Detecting trade-based manipulation by finding suspicious trading patterns in structured data has already been well examined and employed in market surveillance IS (Cao & Ou, 2008). Regarding the one behind the manipulation, one expert states: "A bad guy is engaged in the market, is interested in selling after he buys low, and starts to spreads highly positive news on the social net." The detection of information-based manipulation in recognition of suspicious information published on social media, together with the detection of trade-based manipulation, was therefore mandatory for this research. The systems combine structured data with unstructured social media data to aid in decision making:

The data: The ability to deal with heterogeneous data (R5).

Regulatory authorities often recommend transparency of adaptive management while emphasizing specific processes (Linkov et al., 2006) such as the detection of suspicious patterns in a historical time series of data, the investigation of the transaction, and the escalation to the regulatory authority if necessary (Buta & Barletta, 1991; Lucas, 1993). According to one project expert, financial institutions have to provide the regulatory authority with "detailed information on every potentially abusive case". This implies the following general requirements:

The rules: Must be comprehensive (R6).

Documentation of rules: Alerts need to be processed and stored for investigative purposes (R7).

The subsequent general requirements are for the precise detection of abusive cases (suspicious behaviour) and the provision of signals if suspicious behaviour appears:

The history: The user must have the ability to prove the background of the case that caused an alert (R8).

So as not to overwhelm users with false alarms, as is the case when the rules are too sensitive, the user needs to be authorized to change the rules to a more balanced level. The ability to modify the elements in order to both receive all relevant abusive cases and reduce the appearance of false alerts is further expected with the cost-reducing measures. This implies the final general requirement:

Ability to modify the model configurations: The values of the rules can be changed by the user (R9).

Hence, the unit of analysis in the proposed research was the financial market surveillance decision support system. This system provides all the relevant information necessary to support the regulatory decision making processes. The requirements were evaluated within the team with the purpose of ensuring design theory generalizability, which applies to the class of surveillance systems instead of an instance (Müller-Wienbergen & Müller, 2011). In addition, the developed solutions were presented to the European Commission by the project leaders, presenting achievements and discussing possible modifications of the solutions.

4.2 General Components

General requirements derived from interviews with the practitioners in several cycles provided guidance in order to develop suitable IT solutions. Through abstraction and learning general IT components were identified on this basis. In the following, the abstract architecture of the proposed explanatory design theory is presented.

The data sources that will be considered in the market surveillance task are retrieved from the internal sources of the specific organization and from external data sources. The external structured data is usually provided by data vendors via proprietary IS and other delivery systems. The unstructured textual data is collected from the regulatory authority's web sites. Further unstructured data considered in this project was user-generated content collected from several social networks such as blogs. The regulatory data and user-generated content data have not been fully acknowledged in prior research. Thus, a promising research approach may be achieved by assessing all three of these data sources (regulatory-, vendor- and user-generated content). The value-added components for modern surveillance solutions are:

Internal and external data capturing systems (C1)[2]**.**

The acquisition of a web data stream can be realized with web APIs, (e.g., Twitter™ API). Such stream-based workflows (up-to-date with the stream) can be built on data mining models, allowing client queries at any time (Saveski & Grcar, 2011). The unstructured data relevant for market surveillance retrieved from external sources, such as blogs, tweets, news web pages, and regulatory web pages, is stored here. This data is

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[2] FIRST Consortium D3.1 Semantic resources and data acquisition; D3.3 Large-scale ontology reuse and evolution, http://www.project-first.eu/public_deliverables.

characterized as highly informative (Zhang & Skiena, 2010), and can be used to assess the investors' opinions (Klein, Altuntas, Riekert, & Dinev, 2013). The data retrieved from data vendors, such as structured financial time series data, can also be processed and analysed using data mining techniques (Gopal, Marsden, & Vanthienen, 2011). The general requirements for rules 2, 4, and 5 are thus satisfied. Consequently, the component that provides these services can be taken into account is:

Data storage and analysis (C2)[3].

For the huge amounts of unstructured data, techniques for extracting and adapting information from the text are necessary (Park & Song, 2011). Thus the component comprises the preparation of unstructured data for further use in the workflow process. For this purpose, the scientific literature offers two different approaches, namely ontology-based methods and data mining methods (Klein, Altuntas, Häusser, & Kessler, 2011). Ontology is the formal specification of the vocabulary and its relationships in the domain (Gruber, 1993). The data mining method, particularly the text mining method, deals with the transformation of the natural text into numerical vector values (Feldman & Sanger, 2007). For the purpose of sentiment analysis, one of the sophisticated techniques is the 'active learning principle' where the output is represented by the model for sentiment classification, (e.g., positive or negative financial tweets) (Saveski & Grcar, 2011). In order to maintain the time-critical surveillance tasks of compliance officers, the methods for automatic sentiment classification are obligatory, satisfying general requirements 1 and 2. The component is therefore the further value-added component for modern surveillance solutions:

Processing of unstructured data (C3)[4].

The data applied from the data processing unit serves as input to the knowledge repository, allowing the user to assess the data. Furthermore, as the repository meets general requirement 8 by comprising the information from internal databases and further external data sources, it stores all involved data in the alert signal. The data is further utilized by several models and rules and is stored in the repository. The models to which this research refers are quantitative data mining models, qualitative multi-attribute models, and further market surveillance rules that can detect market anomalies or abusive behaviour ("Project FIRST," 2013). Qualitative multi-attribute models were developed in the interviews with experts and were suitable for the evaluation and analysis of decision alternatives (Bohanec, Žnidaršič, Rajkovič, Bratko,& Zupan, 2013). The data mining models that handle forecasting from large unstructured and structured data sets for the detection of notable or suspicious patterns were also developed. Thus, the following component satisfies general requirements 3, 6, 7, 8, and 9:

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[3] FIRST Consortium D6.5 Highly Scalable Interactive Visualization of Textual Streams v2, http://www.project-first.eu/public_deliverables.
[4] FIRST Consortium D4.3 Large-scale Semantic Information Extraction Components; http://www.project-first.eu/public_deliverables.

Glass-box model of the knowledge repository (C4)[5].

The component should ensure an enhanced understanding of the occurring phenomena and facilitate the decision making processes for the compliance officer. With visualization of the text mining results, along with the qualitative multi-attribute results, the user is deeply involved in the processes of alert generation. The most appropriate visualization can be represented as a decision tree (Liu & Salvendy, 2007) viewed graphically as a set of connected decision nodes and leafs. While the nodes carry the attribute values, the user can use their tacit knowledge regarding pattern recognition and change the attribute values if necessary. This ensures a better understanding of the data samples. This component fulfils general requirements 6, 8, and 9 by employing rule-based methodologies for comprehensibility of rules, vivid representation of the history of occurrence, and ease in rule modification:

Graphical user interface (C5)[6].

For flexibility, financial market surveillance DSS needs to be modular, and the solution can be integrated into existing systems. Table 2 summarizes the contributions this study makes to the scientific knowledge.

General Requirements	General Components
(R1) Proper functioning of capital markets in accordance with the regulation rules.	(C1) Internal and external data capturing systems.
(R2) The user is supported in his daily efforts to maintain observations of market participants' abusive behaviours.	(C2) Data storage and analysis.
(R3) If an anomaly occurs, an alert will be generated.	(C3) Processing of unstructured data.
(R4) Timely analysis of large number of financial instruments.	(C4) Glass-box model of the knowledge repository.
(R5) Use of heterogeneous data.	(C5) Graphical user interface.
(R6) Comprehensive rules.	
(R7) The rules can be configured by the user.	
(R8) Storage of alerts for investigative purposes.	
(R9) The user has the ability to prove the background of the case which caused an alert.	

Table 2. Design theory for financial market surveillance DSS

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[5] FIRST Consortium D6.2 Machine Learning and Qualitative Models; http://www.project-first.eu/public_deliverables.

[6] FIRST Consortium D2.1 Technical requirements and state-of-the-art; http://www.project-first.eu/public_deliverables.

5 Conclusion

The goal of this research on explanatory design theory development was to support decision making for market surveillance enforcement. The approach of theory development was based on the development of an instantiated IT artefact addressing identified user requirements. The emerging qualitative data exploration of semi-structured interviews with team members was carried out with the goal of determining important decision attributes where the exploration was predicated by ADR. Further, an explanatory theory-building method was applied.

From a practical perspective, the general requirements and components represent the design theory that provides guidance for the development of market surveillance IS. Furthermore, from the cost perspective, where market surveillance is emphasized as a time consuming cost centre, this study provided insights into the development of more efficient surveillance systems.

From a theoretical perspective, this research contributes to the literature on financial market surveillance by enhancing future development strategies of explanatory design theories to solve a class of problems. The theory development approach was based on prescriptive research, and accordingly, it built on the suggestions for development.

This research is limited by the fact that it is based on interviews with European domain experts and regulatory authorities. It could be argued that non-European experts have a different point of view of market surveillance. Additionally, this research considers only English articles. Future research could be enhanced by adding non-EU regulatory authorities and by utilizing non-English data sources.

To reduce bias during the project phase, the researchers tried to remain in close contact via email, Skype™, team views, and face-to-face meetings with the experts. Even so, there could be limitations in researcher bias due to the fact that the researchers' goals and those of the expert's sometimes differed, leading to restriction in generalization.

Acknowledgments

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