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# An ontology for causal relationships between news and financial instruments

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## Abstract

In recent years, people have begun to pay more and more attention to the effect of news on financial instrument markets (i.e., the markets for trading financial instruments). Researchers in the financial domain have conducted many studies demonstrating the effect of different types of news on trade activities in financial instrument markets such as volatility in trade price, trade volume, trading frequency, and so on. In this paper, an ontology for knowledge about news regarding financial instruments is provided. The ontology contains two parts: the first part presents a hierarchy framework for the domain knowledge that primarily includes classes of news, classes of financial instrument markets participants, classes of financial instruments, and primary relations between these classes. In the second part, a causal map is used to demonstrate how classes of news are causally related with classes of financial instruments. Finally, a case concerning the “9/11 American terror attack” is analyzed. On the basis of the ontology, it is first comprehensive to understand the knowledge about news in financial instrument markets; second, it helps building trading models based on news in the financial instrument markets; third, systems (e.g., systems for prediction of stock price based on news, systems for supporting financial market participants to search relevant news) design and development in this domain are facilitated and supported by this ontology.

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**Keywords:** Ontology; Causal map; Causal relationships; News; Financial instrument

## 1. Introduction

A financial instrument is defined as a contract that gives rise to a financial liability (or equity instrument) of another entity, highlighting the fact that financial instruments represent a store of value without possessing an intrinsic value of their own.<sup>1</sup> Over the past years, quantities trade models and algorithms (e.g., statistical techniques) based on numbers representing price movements, volume, and volatility have been used by traders in financial instrument markets. Nowadays, these are still being used to predict financial

instrument markets under the assumptions that changes in price are correlated with past price and that past trends can predict the future of the market. However, [Breatley and Meyers \(2000\)](#) point out that in the stock market, stock prices follow a random path; that is, current changes in price are independent of past prices. A reason for this is that if there are patterns visible in prices, people will follow these patterns immediately, making them worthless for trend prediction. However, news articles regarding financial instrument markets do not have this problem because they are released with implications for the fundamentals of financial instruments that people cannot obtain or confirm beforehand. Recently, in order to make algorithms and models for trading in financial instrument markets more predictive and less reactive, people in the field have been considering real-time news as feed for their trading models. Some experts in Wall-Street quants group have predicted that the next generation of algorithms may be

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<sup>1</sup> <http://www.ecb.int/pub/pdf/other/statisticalclassificationfmi200507en.pdf>.

based on news events.<sup>2</sup> In fact, Monitor110 Inc. is developing software that can aid in providing relevant and timely news for financial investors from a large number of information sources.<sup>3</sup>

It is the goal of our paper to propose an ontology demonstrating the domain knowledge about news in the financial instrument markets. It comprises two parts. The first part, which is represented using OWL DL (which is a sublanguage of Web Ontology Language), provides a hierarchy framework for the domain knowledge, including primarily classes of news, classes of financial instrument markets participants, classes of financial instruments, and relations between these classes. This part is a specification of the domain-specific vocabulary of entities, classes, properties, predicates, and functions as a set of relationships that exists among these vocabulary terms. In the second part, a causal map is used to demonstrate how classes of news are causally related with classes of financial instruments. In the causal map, the effect of classes of news events on financial instruments is of either a direct or indirect “cause-effect” form (Lee, 1992), which can be written as rules using the OWL rules language (Horrocks et al., 2005). This second part also considers the reality that market psychology has an effect on financial instruments when the financial instrument markets participants receive news information of a certain character. The ontology in the paper provides not only a formal description of objects in the domain knowledge and shared terminology, but also a formal basis for reasoning domain knowledge. Thus, on the basis of the ontology, it is first comprehensive to understand the knowledge about news in financial instrument markets; second, it helps building trading models based on news in the financial instrument markets; third, systems (e.g., systems for prediction of stock price based on news, systems for supporting financial market participants to search relevant news) design and development in this domain are facilitated and supported by the ontology.

To date, most of the related research has been about systems design and development based on quantities analysis trade models in financial markets such as Roh (2006). Only a few studies have been conducted based on qualitative analysis trade models, and no formal representation of the domain knowledge has been provided. Bunningen (2004) focused on the question of how to predict the reaction of the stock market to news articles using the latest relevant developments in Natural Language Processing. In that study, it was assumed that each category of articles has a certain influence on the stock price, news articles were classified as “positive” or “negative”. Past news articles and past price were taken as input, from which a model was built, and correlations in the model were found between these news articles and changes in stock price.

Bunningen did this research with data mining techniques, and classified news information as “positive” or “negative” but did not consider the causal relationships between variables in news articles.

Hong and Han (2002) designed ways to apply news information on the Internet to the prediction of interest rates, and used cognitive maps to represent the knowledge of interest rate experts, according to which, news information on the Internet was searched and retrieved. This cognitive map did not consider news classifications; thus, the extensibility of the cognitive map as well as vocabulary terms is limited, and news information searching and retrieving based on it are also limited.

The rest of this paper is organized as follows. OWL DL, OWL rules language, and causal maps technologies will be explained in detail in Section 2. Section 3 provides the hierarchy ontology for knowledge about news in financial instrument markets. The causal map in the domain will be proposed in Section 4. Finally, a case is analyzed in Section 5 using the ontology, and we conclude in Section 6.

## 2. Related techniques

OWL DL is primarily used here to represent the ontology and OWL rules language complements OWL DL.

### 2.1. OWL DL

An OWL is a Web Ontology Language. It is designed for use by applications that need to process the content of information instead of just presenting information. It allows more vocabulary terms could be used for describing properties and classes. The main advantages of OWL are efficient reasoning support, sufficient expressive power, and convenient expression (Hsu & Kao, 2005).

OWL offers three sublanguage: OWL Lite; OWL DL; OWL Full. OWL DL supports those users who want the maximum expressiveness while retaining computational completeness and decidability. In our study, OWL DL is suitable for representing the variety types of classes and relationships in the ontology.<sup>4</sup>

In the ontology, each class is a subclass of Things class, Objectproperty links classes or instances and Datatypeproperty links attributes of classes and data type such as strings, Boolean, time and so on.

### 2.2. OWL rules language

Although OWL Web Ontology Language has considerable expressive power, it has expressive limitations, particular with respect to what can be said about properties. Zhang (2006) extends OWL DL with a form of rules to overcome these limitations.

<sup>2</sup> [http://www.wallstreetandtech.com/showArticle.jhtml;jsessionid=51ARDLYI5K302QSNLPSKH0\\_CJUNN2JVN?articleID=185302817](http://www.wallstreetandtech.com/showArticle.jhtml;jsessionid=51ARDLYI5K302QSNLPSKH0_CJUNN2JVN?articleID=185302817).

<sup>3</sup> <http://www.monitor110.com/>.

<sup>4</sup> <http://www.w3c.org/2004/owl/>.

The proposed rules are of an implication form between an antecedent (body) and consequent (head). Both the antecedent and consequent of a rule consist of zero or more atoms. The informal meaning of a rule can be read as: whenever the conditions specified in the antecedent hold, then the conditions specified in the consequent will also hold.

Atoms in rules can be of the form  $C(x)$ ,  $P(x, y)$ ,  $Q(x, z)$ ,  $\text{sameAs}(x, y)$  or  $\text{different}(x, y)$ , where  $C$  is an OWL DL description,  $P$  is an OWL DL individual-valued Property,  $Q$  is an OWL DL data-valued Property,  $x$  and  $y$  are either variables or OWL individuals,  $z$  is either a variable or an OWL data value.

Example: Rule  $A \rightarrow B$  where  $A$  is antecedent,  $B$  is consequent, and if  $A$  holds, then  $B$  will also hold.

### 2.3. Causal maps

A causal map offers to model interrelationships among a variety of concepts, it can be employed to cope with the type of complicated problems for which analytical techniques are inadequate. It is one of five generic types of cognitive maps, and is currently, has been, and is still the most popular mapping method (Chaib-Draa, 2002). When a causal map is pictured in graph form, it is relatively easy to see how concepts and causal relationships are related to each other and to see the overall causal relationships of one concept with another.

A causal map  $M$  is a pair,  $M = (C, E)$ , where  $C$  is a set of nodes, or concepts, and  $E$  is a set of signed edges (Wellman, 1994).

$E = \{(c, c', \delta) : c, c' \in C, \text{ there is an edge of sign } \delta \text{ from } c \text{ to } c'\}$ . The possible signs are usually “+”, “−”, “0” and ambiguous relationship of sign “?”, they respectively denote “ $c$  has increasingly effect on  $c'$ ”, “ $c$  has decreasingly effect on  $c'$ ”, “ $c$  has no effect on  $c'$ ”, “ $c$  has ambiguous effect on  $c'$ ”.

Usually, there are two types of concept events in causal maps: Existential and directional. For  $c \in C$ ,  $c$  is an existential event.

Positive existence, denoted by  $c(+)$ , represents it is known that  $c$  holds.

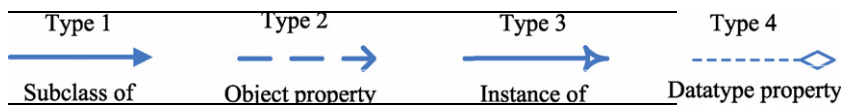
Zero existence, denoted by  $c(0)$ , represents it is unknown whether  $c$  holds or not.

Negative existence, denoted by  $c(-)$ , represents it is known that  $c$  does not hold.

For  $c \in C$ ,  $c$  is a directional event.

Positive change, denoted by  $c(+)$ , represents it is known that  $c$  is rising.

Zero change, denoted by  $c(0)$ , represents it is known that  $c$  is unchanged.



Negative change, denoted by  $c(-)$ , represents it is known that  $c$  is falling.

$(c, c', \delta) ((c, c', \delta) \in E)$  can be written as rule:  $c \xrightarrow{\delta} c'$ .  $c \xrightarrow{+} c'$  means that if  $c$  is “+” (“−”), then  $c'$  will hold as “+” (“−”).  $c \xrightarrow{-} c'$  means that if  $c$  is “−” (“+”), then  $c'$  will hold as “+” (“−”). And  $c \xrightarrow{0} c'$  means that  $c$  has no effect on  $c'$ ,  $c \xrightarrow{?} c'$  means that the effect  $c$  has on  $c'$  is ambiguous.

A causal map graph is a set of event classes connected by arrows, with the direction of the arrow indicating the direction of influence or causality.

The general definition of derived relationships between in an acyclic causal map is simply the sum of the signs for all paths between them. Let  $P_{a,b}$  be the set of paths in  $M$  from  $a$  to  $b$ , then the sign of derived causal relation from  $a$  to  $b$  is:

$$\bigoplus_{p \in P_{a,b}} \left( \bigotimes_{(c, c', \delta) \in p} \delta \right)$$

The primary emphasis in causal maps is in identifying dependence between variables with explanation-consequence or means-end relationships. There are different techniques employed to construct causal maps, including structured methods such as the self- $Q$  method, open method based on personal construct theory, and textual analysis approach (Nadkarni & Shenoy, 2001). In the paper, we construct the causal map through a study of literatures in financial domain by textual analysis approach.

### 3. Ontology

A domain ontology defines the set of basic terms comprising the vocabulary of the domain area and the relationships that bind these terms (Xu et al., 2005).

The ontology for relationships between news and financial instruments comprises four parts, each of them is presented by one figure. In the ontology of our study, rational criteria are adopted to classify the domain entities such as news and financial instruments, by which knowledge in the domain is comprehensive to understand.

#### 3.1. Classes of the ontology

Trade activities in financial instrument markets are directly affected by news and trader's psychology and behaviors when they receive news (Chan, 2003). The ontology which represents the causal relationships between news and financial instruments will include primarily four classes: news class; financial instrument market participants class consisting of information providers and traders; financial instruments class; financial instruments issuers class.

Fig. 1 provides the primary classes of this ontology. Figs. 2–4 complement Fig. 1. In these figures, arrow of type

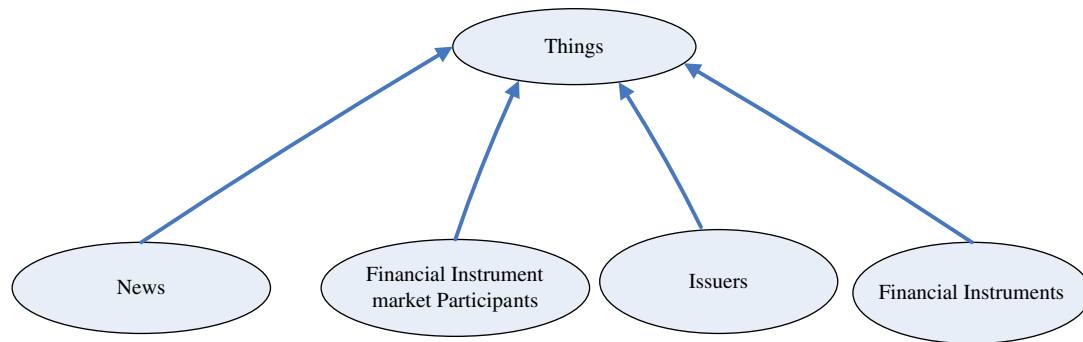


Fig. 1. Classes of the ontology.

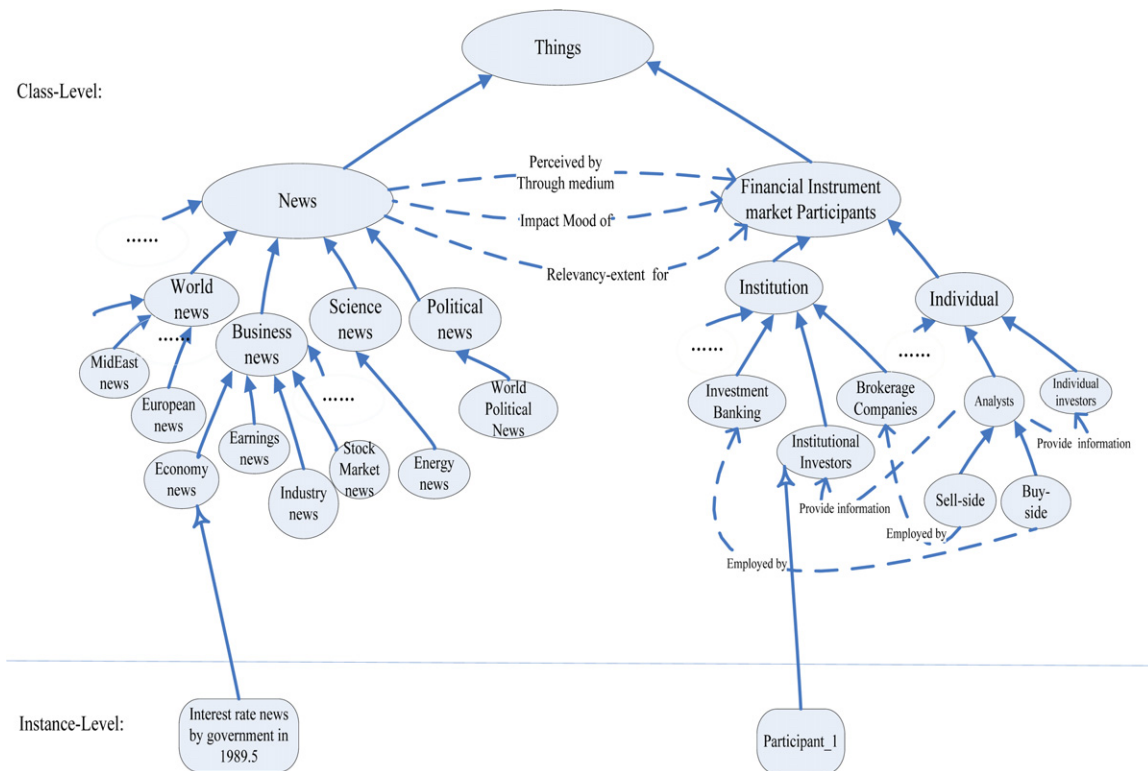


Fig. 2. Relationships between news and financial instrument market participants.

1 links subclass to its parent class, for example, class of News is a subclass of Things class. Arrow of type 2 denotes relationships between classes or instances, arrow of type 3 links instance to its class. Arrow of type 4 denotes relationships between classes and their datatype property. The ontology in Fig. 1 using OWL DL is presented as follows (Table 1).

### 3.2. Relationships between news and participants

In Fig. 2, News is classified according to the classification criteria of Yahoo Web News (Green, 2004). Ken little<sup>5</sup>

has listed categories of news that may cause the financial instrument markets to change direction or speed up or slow down its momentum. His category is mainly consistent with news categories of most website news such as Yahoo Web News, thus, news classification criterion from Yahoo Web is adopted by the ontology in our study. The right side of this figure are the classes of financial instrument market participants. Brokerage companies, investing bank and analysts release information with public news or without public news and most of information they provide is recommendation or advertising news. Analysts can be divided into two types: One is sell-side which is employed by investment bank or brokerages; the other is buy-side which is employed by institutional investors such as mutual fund. Investors in market react to the two types of analysts in dif-

<sup>5</sup> <http://stock.about.com>.

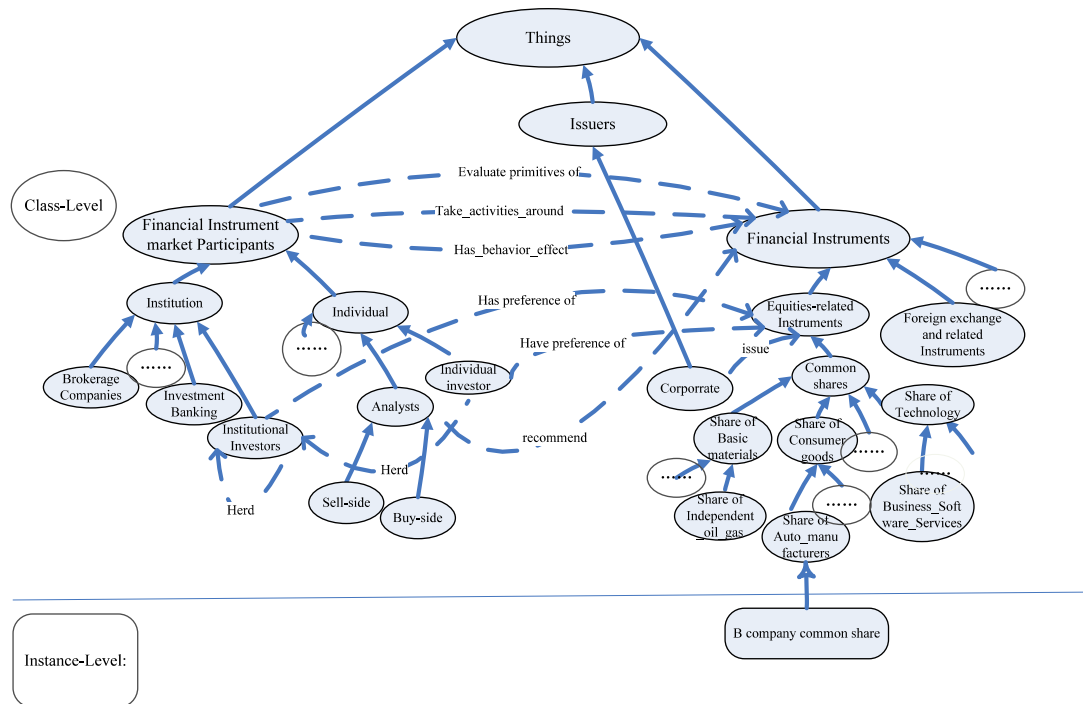


Fig. 3. Relationships between participants and financial instruments.

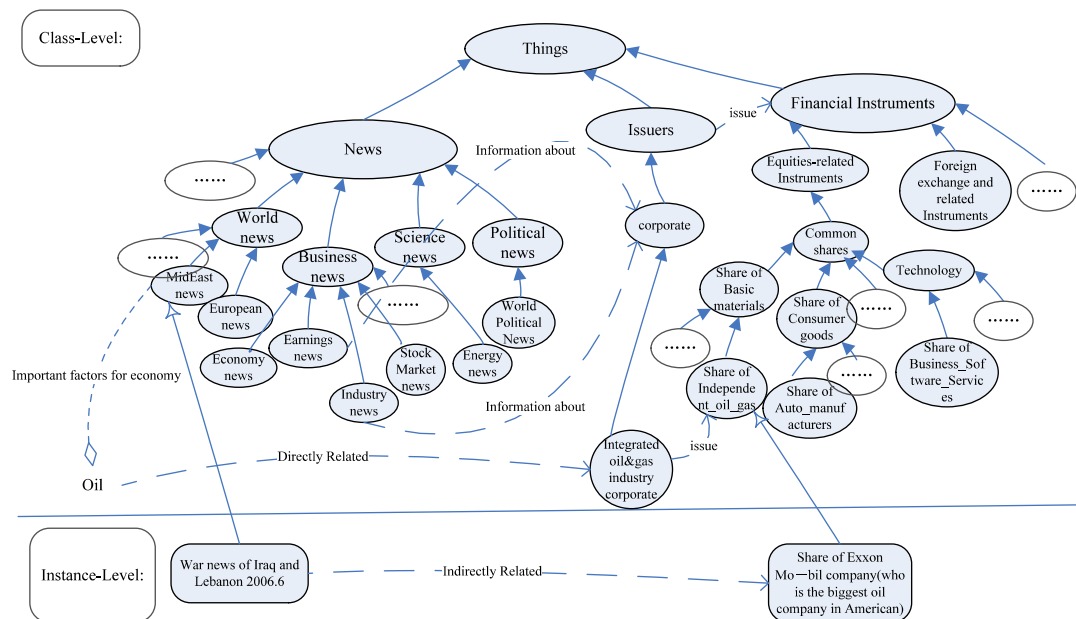


Fig. 4. Relationships between news and financial instruments.

Table 1  
OWL DL definition of the class “news”

```

<owl:Class rdf:about="#News">
  <rdfs:subClassOf rdf:resource="http://www.w3.org/2002/07/owl#Thing"/>
  <owl:disjointWith rdf:resource="#Financial Instruments"/>
  <owl:disjointWith rdf:resource="#Financial instrument market participants"/>
</owl:Class>

```

See more in Appendix A.

ferent ways because traders in financial instrument markets have bias in cognition of information from the two types of analysts (Barron, 1995). The left side in the figure are the classes of news. The dashed open (Type 2) arrows link two different classes, and denote their Objectproperties, for example, the arrow labeled “perceived by through medium” links News class and Financial instrument market participants class, it means that objects in the latter class perceive objects in the former class (Table 2).



Table 2  
OWL DL definition of objectproperty “perceived by through medium”

```
<owl:ObjectProperty rdf:about="# Perceived by through medium">
  <rdfs:range rdf:resource="#Financial instrument market
  participants"/>
  <rdfs:domain rdf:resource="#News"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/
  XMLSchema#string">through medium</rdfs:comment>
</owl:ObjectProperty>
```

### 3.3. Relationships between participants and financial instruments

Classification of financial market instruments in the right side of Fig. 3 is consistent with European Central Bank's work on classification of financial instruments, in which stocks can be classified by industry.<sup>6</sup> In the left side of this figure, with available news, different traders are of different processing information ability, the low ability traders will always follow high ability neglecting their own available information, which is called herding behavior. Herding behavior occurs when investors intensively buy or sell the same financial instrument at the same time. Herding behavior occurs among institutional investors because many of their managers do not take risk to lose credit in face of their clients. And individual investors follow institutional investors because they consider that institutional investors have high processing ability and have a variety of news sources (Nofsinger & Sias, 1999). As the news disseminate in the financial instrument markets along time, participants react differently to these news, followed by collective (macro or aggregate) effect on trade activities in financial instrument markets (Table 3).

### 3.4. Relationships between news and financial instruments

Fig. 4 demonstrates how different classes of news are related with classes of financial instruments. An example: Middle East is the largest oil output area, if wars occur between Iraq and Lebanon, people will consider in the way that this war will affect oil supply, and oil supply is directly related with trading price of shares of the oil companies. So traders who hold oil shares will focus on and react to news that occurs in Middle East. Different investors will focus on different kinds of news according to their interest and experience. In the right side of this figure, equities are shares of companies, and these companies publish information about their earnings and other news about management activities, which are important for participants who own shares of these companies or pay attention to the shares of these companies. Thus, it is also important to concern issuers of the financial instruments (Table 4 and Figs. 5–7).

<sup>6</sup> <http://www.ecb.int/pub/pdf/other/statisticalclassificationfmi200507en.pdf>.

Table 3  
OWL DL definition of object property “recommend”

```
<owl:ObjectProperty rdf:about="#recommend">
  <rdfs:range rdf:resource="#Financial instruments"/>
  <rdfs:domain rdf:resource="#Analysts"/>
  <rdfs:comment rdf:datatype="http://www.w3.org/2001/
  XMLSchema#string">
  </rdfs:comment>
</owl:ObjectProperty>
```

Table 4  
OWL DL definition of datatype “important factors for economy”

```
<owl:DatatypeProperty rdf:ID="important factors for economy">
  <rdfs:domain rdf:resource="#News"/>
  <rdfs:range rdf:resource="http://www.w3.org/2001/
  XMLSchema#string"/>
</owl:DatatypeProperty>
```

## 4. Causal maps in the domain

### 4.1. Domain scenarios analysis

The causal map in Section 4.2 is constructed through a study of literature review. Trading activities of financial instrument markets are always determined by some primitives. For example, equity related instruments have four primary primitives determining price: earning growth, risk-premium, risk free return (non-nominal interest rate), and dividend. Classes of news flowing into financial market affect price through the four primitives (Boyd et al., 2005). For example, when market return uncertainty risk and return risk of company increase, people will expect high risk-premium, expected price will decrease. Interest rate related instruments have one primary primitive: interest rate (Fleming & Remolona, 1997). Other types of financial instruments also have their primitives in the same way.

Each class of news is of one common character. The partial causal relationships between different classes of news events, between news events and primitives are extracted, represented in the causal map.

For economic news, it usually reports macroeconomic variables. In equity related instruments market, according to Flannery and Protopapadakis (2002), Pearce studied macroeconomic variables as excellent candidates for extra-market risk factor for equity related instruments, because macroeconomic changes simultaneously affect many firms' cash flow and may influence the risk-adjusted discount rate(same as the risk free return). Three nominal variables (CPI, PPI, Monetary Aggregate-M1 or M2) and three real variables (Employment Report, Balance of Trade, and Housing Starts) were identified as strong candidates for risk factors. Increased trading volume was also found associated with the six macrovariables. In the interest rate related instruments market, the macroeconomic news such as CPI (Consumer Price Index), PPI (Producer

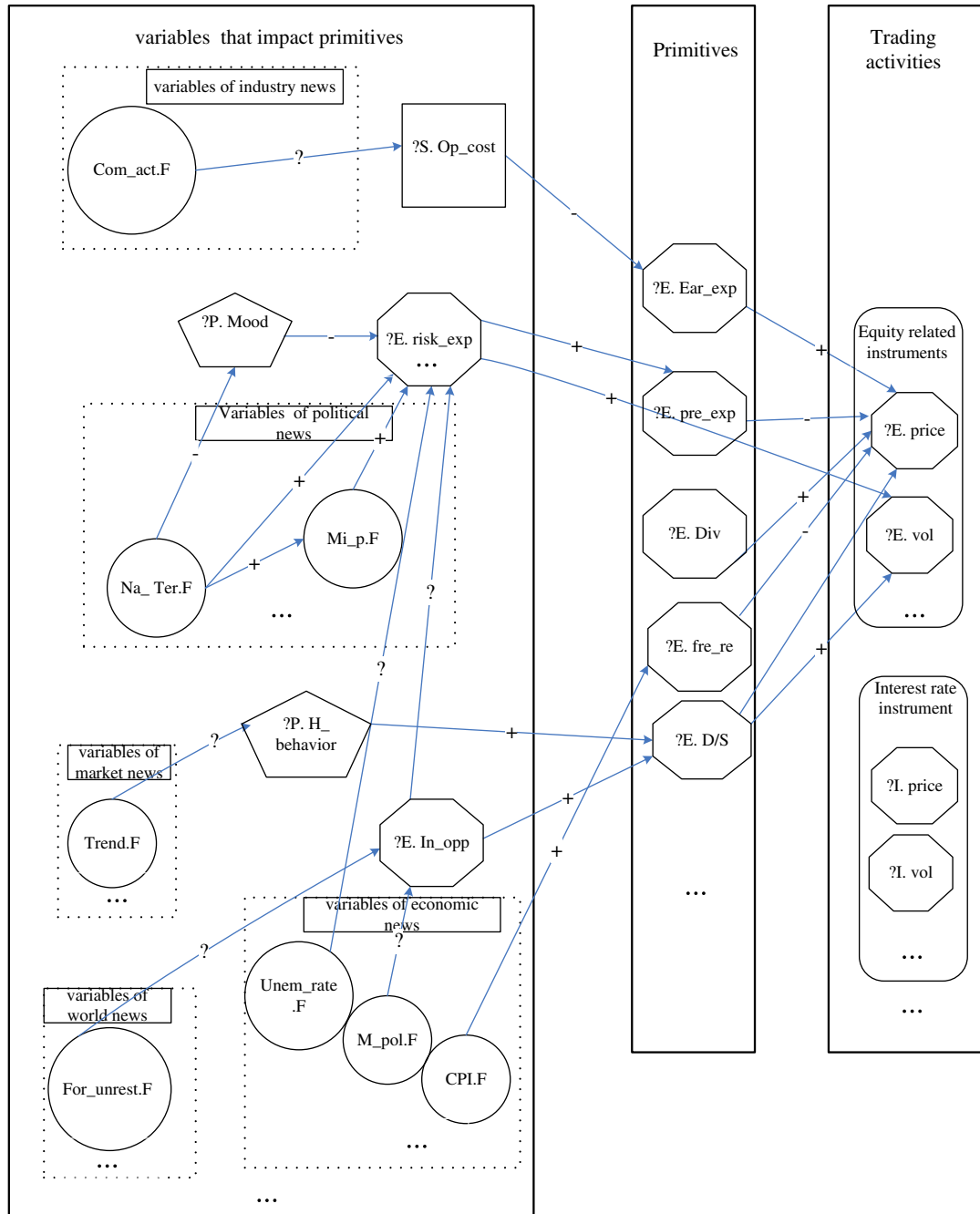


Fig. 5. Causal map for partial relations between news and financial instruments.

Price Index), Money Supply usually imply future trend of interest rate (Fleming & Remolona, 1997).

For the political news, terrorism and related news are the important news that will affect financial instrument markets. Impact of terrorist attacks differs according to the home country of the target firm and the country in which the incident occurs. Terrorism is a geopolitical risk that affects the global economy and financial markets. Those attacks not only have the short-term macroeconomic impact on investors' risk aversion, mood, equity market valuations, bond yields, oil prices (Hamilton argues that oil prices are causal correlated with macroeconomic,

and oil prices impact current or expected cash flow (Jones & Kaul, 1996)), aggregate consumption, investment activity and also have the medium-term effects in the regulatory, trade and fiscal policy responses by governments and the sector. Some experts have suggested that terrorism may make market in the psychological fear of terrorism that can affect investors' mood and economic behaviors. Consumers and speculators in a good mood form more positive expectations about a stock or market products, they are willing to take more risk and more easily convinced to buy, and form more negative market expectations in a bad mood (Raaij, 1989).





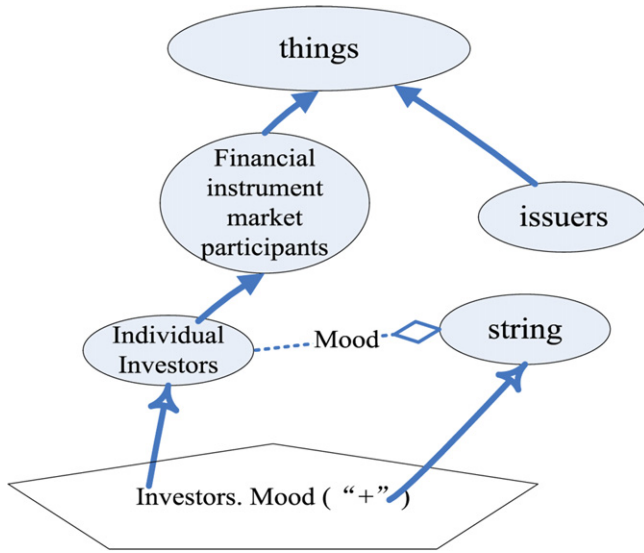


Fig. 7. Graph for Investors.Mood("+").

are properties of individual instances of the classes in the ontology in Section 3. Thus, an OWL language which adds rule atoms provided by Zhang (2006) is adopted here to describe the causal map (Tables 5–8).

Here, for example:

Rule 1: Individual(CPI type(Economic news))  $\wedge$  Value(factsignal "+")  $\rightarrow$  Variable (?E type(Equity related instruments))  $\wedge$  Value(fre-re "+") can be rewritten in the paper as:

Rule 2:  $\text{CPI.F}(+) \xrightarrow{+} ?\text{E.fre} - \text{re}$   
 ... (Tables 9–12)

A causal map is a pair:  $M = (C, E)$

$C = \{\text{Na-ter. F, ?P. Mood}, \dots\}$

$E = \{(\text{Na-ter. F, ?P. Mood}, -), (?E. \text{risk-exp}, ?E. \text{pre-exp}, +), \dots\}$

There are many paths from “fact signal of national terror” to “price of ?E shares” in the above causal map. Only two paths are explained here for simplification ( $a = \text{Na-ter. F}$ ,  $b = ?E. \text{price}$ ).

$$p_1, p_2 \subset P_{a,b}$$

Table 5  
Description for class “news”

```
<owl: classAtom>
  <owlx: Class owlx: name="News"/>
</owl: classAtom>
  DatatypeProperty(factsignal)
  DatatypeProperty(reporttime)
  ...
```

Example:

Individual (CPI type (Economic news))  
 value (factsignal "+")  
 value(report-time "Dem/12th/2006")

(in the causal graph, we use CPI.F to denote the value of  
 Dataproperty: factsignal of the individual CPI)

Table 6  
Description for class “financial instrument market participants”

```
<owlr: classAtom>
  <owlx: Class owlx: name="Financial instrument market
    participants"/>
  <owlr: Variable owlx: name="?P"/>
</owlr: classAtom>
  DatatypeProperty(Mood)
  DatatypeProperty(Herd behavior)
  ...
```

Table 7  
Description for class “equity related instruments”

```
<owlr: classAtom>
  <owlx: Class owlx: name="Equity related instruments"/>
  <owlr: Variable owlx: name="?E"/>
</owlr: classAtom>
  DatatypeProperty(Earning growth expectation)
  DatatypeProperty(Risk-premium expectation)
  ...
```

Example:

Individual (?E type(Equity related instruments))  
 Value(fre-re "+")

(in the causal graph, we use ?E.fre-re to denote the value of  
 Dataproperty: free- return of variable ?E)

...

Table 8  
Description for class “company”

```
<owlr: classAtom>
  <owlx: Class owlx: name="company"/>
  <owlr: Variable owlx: name="?S"/>
</owlr: classAtom>
  DatatypeProperty(operation profit)
  DatatypeProperty(operation cost)
  ...
```

Table 9  
Dataproperty of variables reported in news

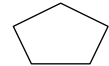
$C_N$



Com-act. F	Fact-signal of Company management activities related news
Na-ter. F	Fact-signal of National terror related news

Table 10  
Dataproperty of variables in participants

$C_P$



?P. Mood	The mood of ?P
?P. H-behavior	Herd behavior of ?P

$$p_1: (\text{Na-ter. F}(+) \xrightarrow{-} ?\text{P. Mood}) \xrightarrow{-} (?E. \text{risk-exp}) \xrightarrow{+} (?E. \text{pre-exp}) \xrightarrow{-} (?E. \text{price})$$


Table 11

Dataproperty of variables in company

$C_S$	
?S. Op-cost	Operation cost of issuer ?S

Table 12

Dataproperty of variables in equity related instruments

$C_E$	
?E. risk-exp	Return uncertainty risk expectation of ?E

$$p_1 = \{(Na-ter. F, ?P. Mood, -), (?P. Mood, ?E. risk-exp, -), (?E. risk-exp, ?E. pre-exp, +), (?E. pre-exp, ?E. price, -)\}$$

$$\otimes \delta_{(c,c',\delta) \in p_1} = -$$

$$p_2: (Na - ter. F(+)) \xrightarrow{?} (Com - act. F) \xrightarrow{?} (?S. Op-profit/cost) \xrightarrow{-} (?E. Ear - exp) \xrightarrow{+} (?E. price)$$

$$p_2 = \{(Na-ter. F, Com-act. F, ?), (Com-act. F, ?S. Op-profit, ?), (?S. Op-profit, ?E. Ear-exp, +), (?E. Ear-exp, ?E. price, +)\}$$

$$\otimes \delta_{(c,c',\delta) \in p_2} = ?$$

(if the national terror crisis is related with the operation profit of Corporate S, then (Na-ter. F, Com-act. F, ?) will be (Na-ter. F, Com-act. F, +))

## 5. Case analysis

This case is about trade activities in New York stock market after 9/11 American terror attack, mainly about what happened to the stock trading activities of CNOOC. (CNOOC is China Ocean Petroleum Corporation, but traded in New York Stock Market.) One abnormal activity was that with the impact of 9/11 attacks, the confidence of investors for most company were affected and most of stock prices decreased while China Ocean Petroleum Corporation increased.

Here are the details about CNOOC. Before 9/11, there were many newspapers reporting that CNOOC had strictly cost control. And the company had set up many new sub-companies to broaden new operations. Thus, future profit-growth for CNOOC was predicted to be high. Additionally, that crude oil production had increased 5.1% was also reported, at the same time, analysts also recommended CNOOC shares, CNOOC was considered to be a highly profit growth company. After 9/11, most of shares in New York Stock Market decreased and investors were in negative mood, and they preferred to seek safe share for fund refuge, because it came to investors' mind that CNOOC was not impacted by 9/11 much as other shares in New York Stock exchange. With high market risk, price of CNOOC shares still increased because of its highly profit growth and safety advantages. All information above can

Table 13

Partial OWL DL definition of instance "terror-attack-9/11 news"

<domestic-political-unrest-news rdf:ID="terror-attack-9/11">
<related-company-counrty rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
>Air company</related-company-counrty>
<ImpactMoodOf rdf:resource="#Individual-investors-of-NewYork-stock-market"/>
<report-time rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime">
>2001-09-11</report-time>
<bad-for rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
>most company and market</bad-for>
<related-palce rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
></related-palce>
</domestic-political-unrest-news>

be referred to "Apple Daily",<sup>7</sup> "XingDao Daily"<sup>8</sup> which are published in HongKong.

In this case, the effect of 911 news event and other news events triggered by 911 on shares of CNOOC and other shares which belong to different classes of financial instruments in New York stock market is analyzed using the causal map in Section 4 and the hierarchy ontology proposed in Section 3 (Table 13).

In this graph, there are seven paths from Na-ter.F to CNOOC-S. price  $\{p_1, p_2, p_3, p_4, p_5, p_6, p_7\}$ , paths  $\{p_8, p_9\}$  cannot affect CNOOC-S. price.  $p_{10}$  affects CNOOC-S. vol.

$$p_1: Na - ter.F(+) \xrightarrow{-} Investor.Mood \text{ (in NY stock market)} \xrightarrow{-} CNOOC - S.risk - exp \xrightarrow{+} CNOOC - S. pre-exp \xrightarrow{-} CNOOC - S. price$$

$$\otimes \delta_{(c,c',\delta) \in p_1} = -$$

(most of the shares in New York Stock Market is impacted by this path after 9/11 terror attack)

$$p_2: Unem - rate.F(-) \xrightarrow{+} CNOOC - S.risk - exp \xrightarrow{+} CNOOC - S.pre - exp \xrightarrow{-} CNOOC - S. price$$

$$\otimes \delta_{(c,c',\delta) \in p_2} = -$$

$$p_3: ("CNOOC \text{ new operations setup"). F(+) \xrightarrow{+} CNOOC.op - profit \xrightarrow{+} CNOOC - S. ear - exp \xrightarrow{+} CNOOC - S. price$$

$$\otimes \delta_{(c,c',\delta) \in p_3} = "+"$$

$$p_4: Crude oil profit(+) \xrightarrow{+} CNOOC.op - profit \xrightarrow{+} CNOOC - S. ear - exp \xrightarrow{+} CNOOC - S. price$$

$$\otimes \delta_{(c,c',\delta) \in p_4} = "+"$$

$$p_5: Na - ter.F(+) \xrightarrow{+} CNOOC - S.In - opp \pm CNOOC - S. D(+) \xrightarrow{+} CNOOC - S. price$$

<sup>7</sup> <http://www1.appledaily.atnext.com>.

<sup>8</sup> <http://www.cwrank.com/super/hit.php?id=30068>.

$$\otimes \delta_{(c,c',\delta) \in p_5} = “+”$$

$p_6$ : Analysts Recommend CNOOC – S(+) $\xrightarrow{+}$  CNOOC – S.In – opp $\xrightarrow{+}$  CNOOC – S. D $\xrightarrow{+}$  CNOOC – S. price

$$\otimes \delta_{(c,c',\delta) \in p_6} = “+”$$

$p_7$ : Interest Rate.F(–) $\xrightarrow{+}$  CNOOC – S. fre – re $\xrightarrow{+}$  CNOOC – S. price

$$\otimes \delta_{(c,c',\delta) \in p_7} = “+”$$

$p_8$ : Na – ter.F(+) $\xrightarrow{0}$  CNOOC.op – profit

$$\otimes \delta_{(c,c',\delta) \in p_8} = “0”$$

$p_9$ : Na – ter.F(+) $\xrightarrow{0}$  CNOOC.op – cost

$$\otimes \delta_{(c,c',\delta) \in p_9} = “0”$$

$p_{10}$ : Na – ter.F(+) $\xrightarrow{+}$  CNOOC – S.In – opp $\xrightarrow{+}$  CNOOC – S. D $\xrightarrow{+}$  CNOOC – S. vol

$$\otimes \delta_{(c,c',\delta) \in p_{10}} = “+”$$

Paths set  $\{p_1, p_2, p_3, p_4, p_5, p_6, p_7\}$  affect trading price of CNOOC shares. Sum of the effect on CNOOC from positive paths set:  $\{p_3, p_4, p_5, p_6, p_7\}$  is larger than negative paths:  $\{p_1, p_2\}$ , thus CNOOC could be one of increasing share after 9/11 terror attack. However, most of other shares in New York Stock Market which were mainly affected by the negative paths including  $\{p_1, p_2\}$  fell in trading prices.

## 6. Conclusions

In the paper, an ontology for knowledge about news in financial instrument markets is provided. The ontology contains two parts: The first part presents a hierarchy framework for the domain knowledge including primarily classes of news, classes of financial instrument markets participants, classes of financial instruments, and relations between these classes. The second part is a causal map. It is used to demonstrate how classes of news are causally related with classes of financial instruments. There are three contributions of our study: on the basis of the ontology,

1. It is comprehensive to understand the knowledge about news in financial instruments market.
2. It helps building trade models based on news in the financial instrument markets.
3. Systems (e.g., systems for prediction of stock price based on news, systems for supporting financial market participants to search relevant news) design and development in this domain are facilitated and supported by the ontology.

In further research, a prediction system for stock prices will be designed that considers news as feed for the trading models based on the ontology.





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## Appendix A

```
<owl:Class rdf:ID="Financial instrument market
participants">
<rdfs:subClassOf rdf:resource="http://www.w3.org/
2002/07/owl#Thing"/>
<owl:disjointWith>
<owl:Class rdf:about="#News"/>
</owl:disjointWith>
</owl:Class>
<owl:Class rdf:about="#Financial instruments">
<rdfs:subClassOf rdf:resource="http://www.w3.org/
2002/07/owl#Thing"/>
<owl:disjointWith>
<owl:Class rdf:about="#News"/>
</owl:disjointWith>
</owl:Class>
...
```

## Appendix B

$C_N$	
Com-act. F	Company management activities. Fact-signal
Na-ter. F	National terror. Fact-signal
Mi-p. F	Military policy. Fact-signal
Trend. F	Market Trend. Fact-signal
F-unrest. F	Foreign Unrest. Fact-signal
Unem-rate. F	Unemployment rate. Fact-signal
M-pol. F	Money policy. Fact-signal
CPI. F	CPI. Fact-signal
$C_P$	
?P. Mood	The mood of ?P
?P. H-behavior	Herd behavior of ?P
$C_S$	
?S. Op-cost	Operation cost of issuer ?S
$C_E$	
?E. risk-exp	Return uncertainty risk expectation of ?E

(continued on next page)

**Appendix B** (*continued*)

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?E. In-opp	Investment opportunity for ?E
?E. Ear-exp	Earning growth expectation of ?E
?E. pre-exp	Risk premium expectation of ?E
?E. Div	Dividend of ?E
?E. fre-re	Risk free return of ?E
?E. D/S	Demand/Supply of ?E
?E. price	Trading price of ?E
?E. vol	Trading volume of ?E

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