TaxoLearn: a Semantic Approach to Domain Taxonomy Learning

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Introduction

- Taxonomies important in information science
- Manually construction is time consuming
  - requires expert knowledge
- Solution = taxonomy learning
  - automatically construct taxonomy given a corpus of data

Introduction

Aspects in taxonomy learning

- data sparseness
- syntactical structure vs semantics
- relevance of concepts
- relations between concepts

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TaxoLearn

- Requires:
  - corpus of documents of interest
  - corpora of documents unrelated to the domain of interest
- Outputs:
  - taxonomy of *concepts*, deduced from the provided documents of interest

TaxoLearn

1. Find (disambiguated) candidate concepts
2. Select relevant concepts
3. Determine concept similarities
4. Construct and label taxonomy

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1. Find candidate concepts

The stock market was heavily shaken after the European Bank lowered the interest rates.

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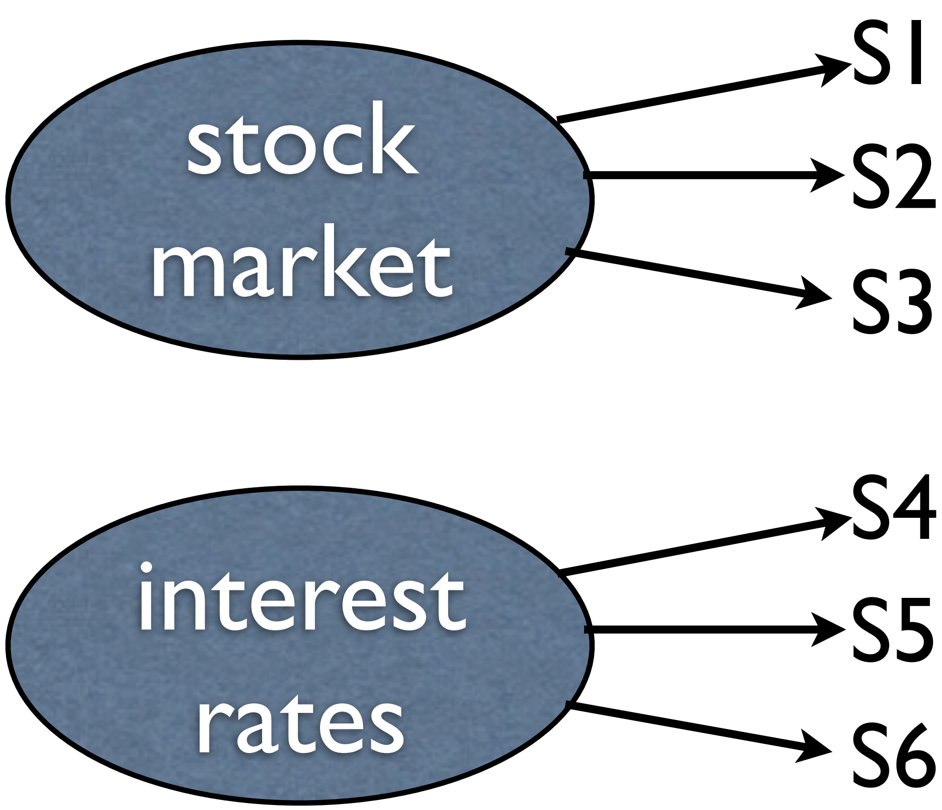
link to WordNet synsets



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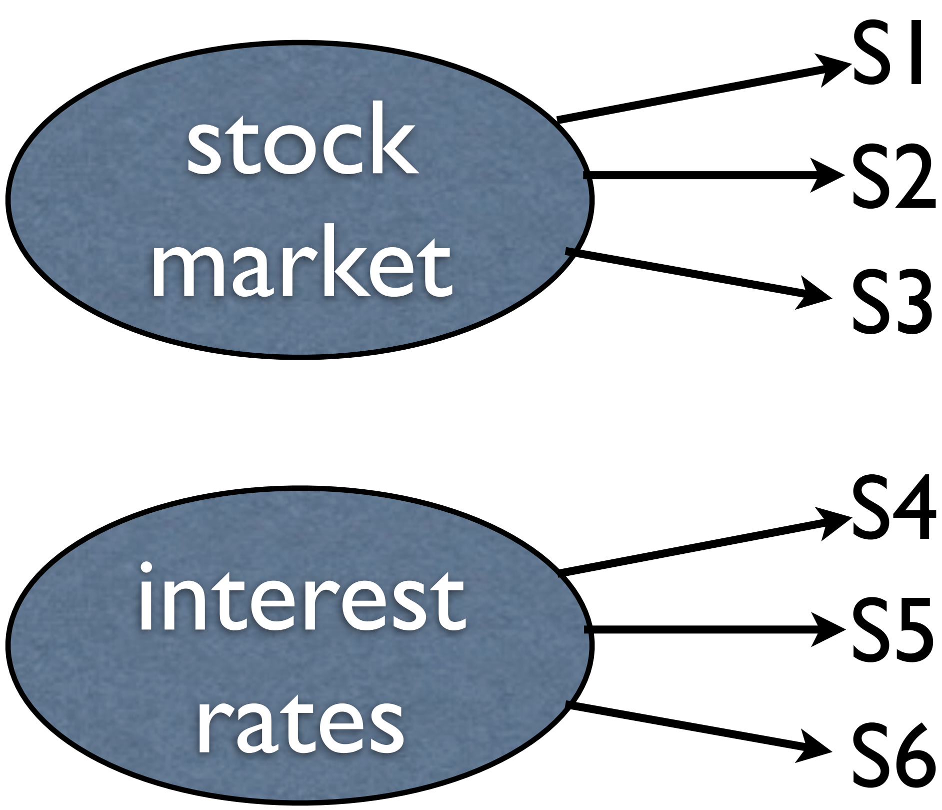

$$\mathrm{KPP}(v, V) = \frac{\sum_{u \in V : u \neq v} \frac{1}{d(u,v)}}{|V| - 1}$$

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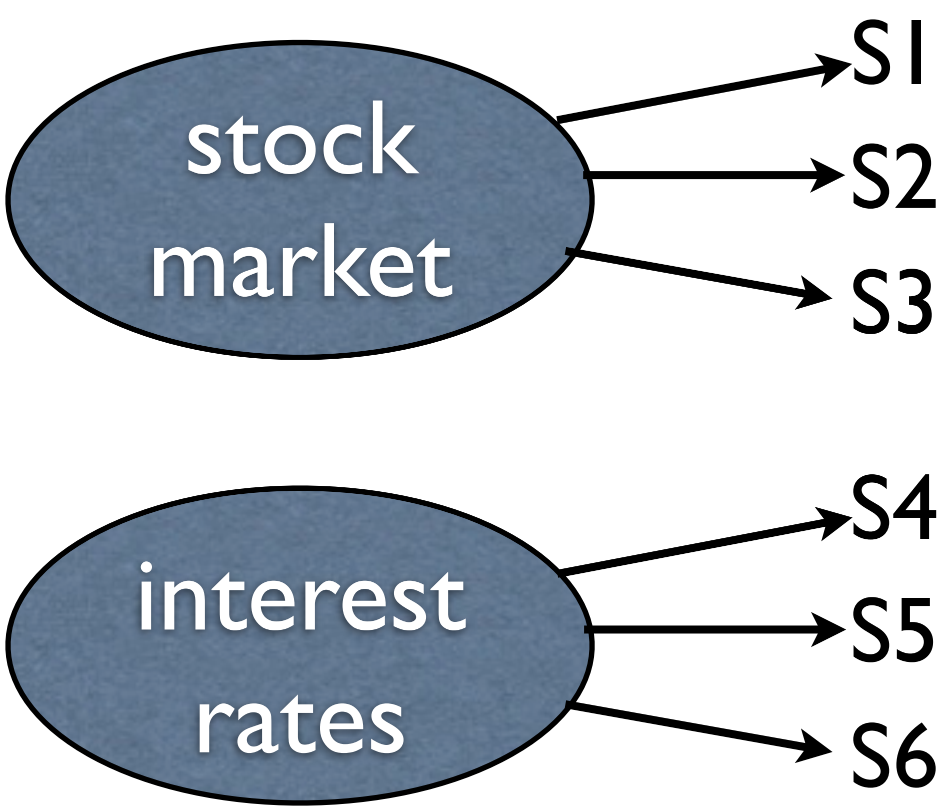

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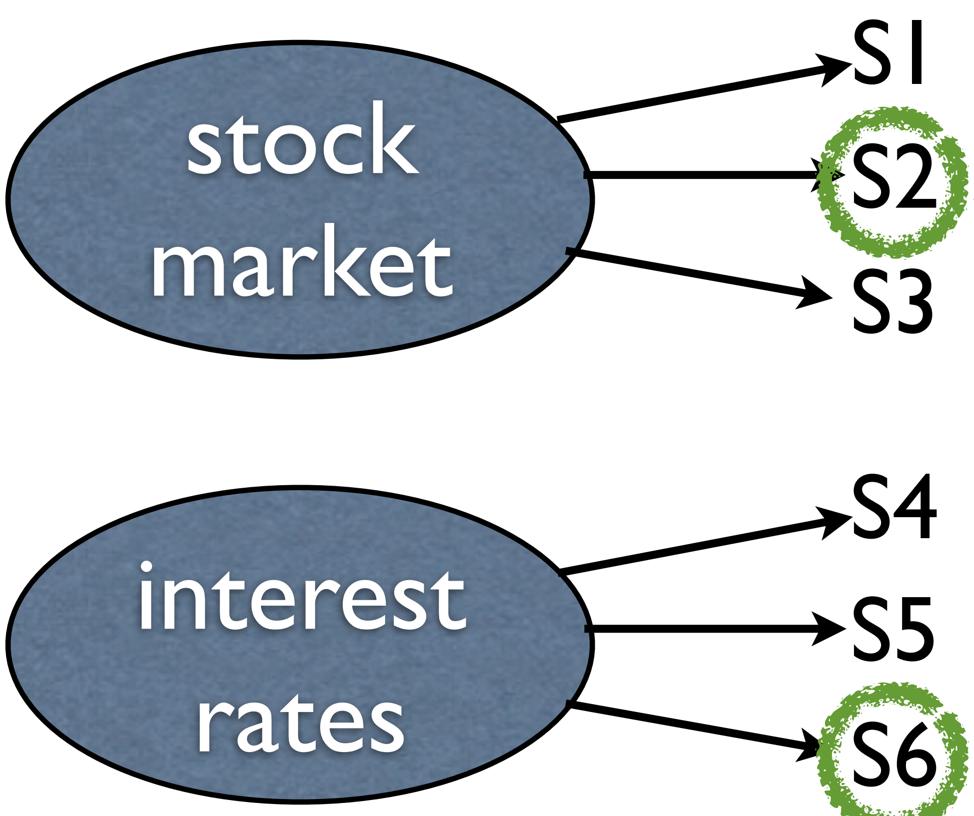

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2. Select relevant concepts

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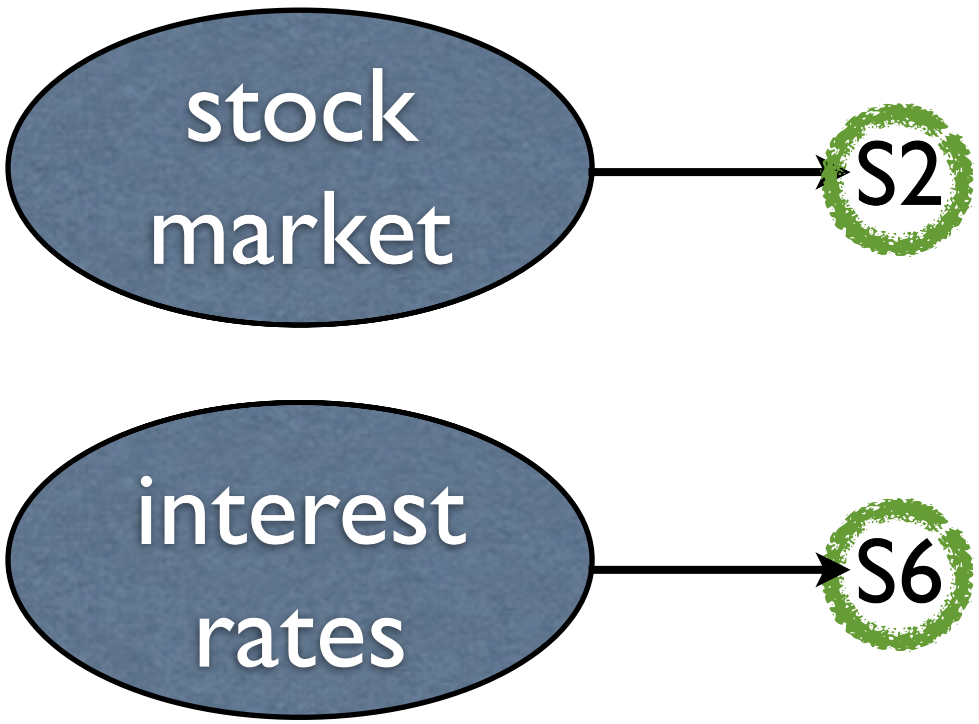

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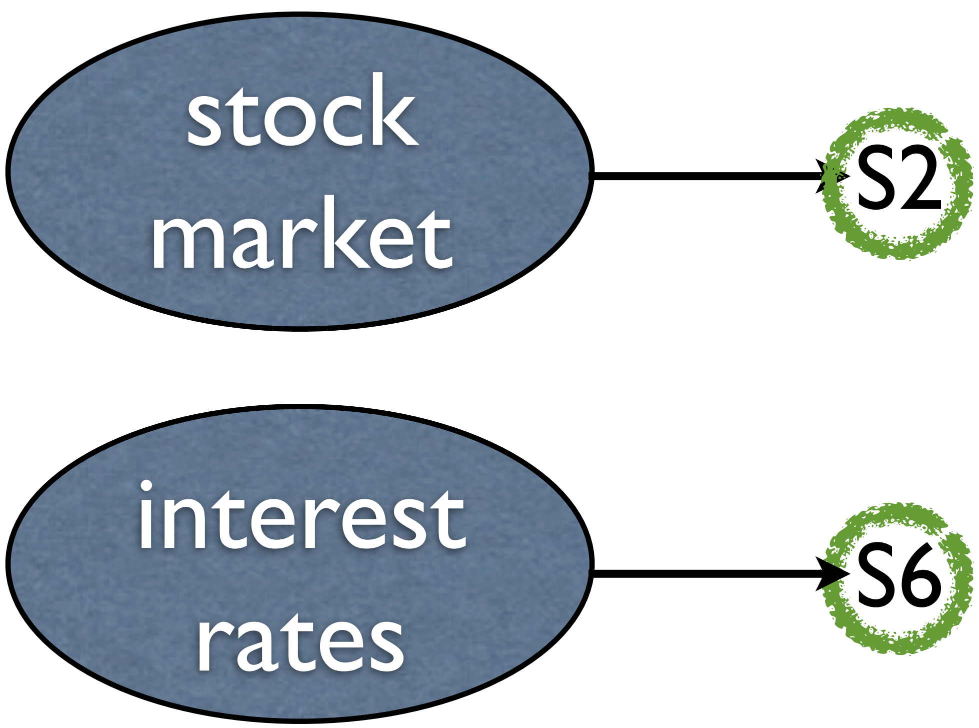

Use two filters:

- Domain Pertinence

$$\mathrm{DP}(c, D^*) = \frac{\mathrm{freq}(c, D^*)}{\max_{j, D_j \neq D^*}\left(\mathrm{freq}(c, D_j)\right)}$$

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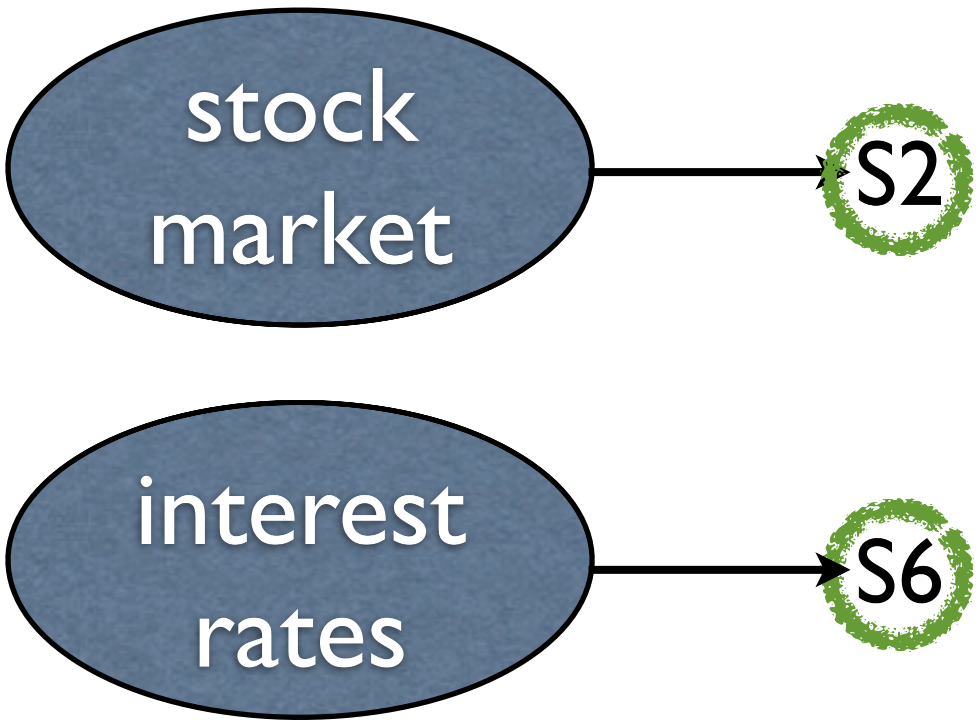

Use two filters:

- Domain Pertinence

$$\mathrm{DP}(c, D^*) = \frac{\mathrm{freq}(c, D^*)}{\max_{j, D_j \neq D^*} \left(\mathrm{freq}(c, D_j)\right)}$$

- Domain Consensus

$$\mathrm{DC}(c, D^*) = -\sum_{d_k \in D^*} \mathrm{norm\_freq}(c, d_k) \times \log\left(\mathrm{norm\_freq}(c, d_k)\right)$$

with

$$\mathrm{norm\_freq}(c, d_k) = \frac{\mathrm{freq}(c, d_k)}{\max(\mathrm{freq}(c, D))}$$

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3. Determine concept similarities

Three methods for computing similarity:

- The WordNet method
- The PMI method
  (Pointwise Mutual Information)
- The Web method

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3. Determine concept similarities

The WordNet method

$$\mathrm{sim}_{\mathrm{WN}}(c_i, c_j) = \frac{1}{d(c_i, c_j)}$$

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3. Determine concept similarities

The PMI method

$$\mathrm{sim}_{\mathrm{PMI}}(c_i, c_j) = \log \frac{F_{c_i \cap c_j} / F_{all}}{\left(F_{c_i} / F_{all}\right) \times \left(F_{c_j} / F_{all}\right)}$$

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3. Determine concept similarities

The Web method

$$\mathrm{sim}_{\mathrm{WEB}}(c_i, c_j) = \log \frac{H_{c_i \cap c_j} / H_{all}}{\left(H_{c_i} / H_{all}\right) \times \left(H_{c_j} / H_{all}\right)}$$

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4. Construct and label taxonomy

Constructing the taxonomy

- Hierarchical clustering is used for the WordNet, PMI, and Web method
- Advantages:
  - Able to inspect dendogram
  - Average linkage is used

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Labeling the taxonomy

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Labeling the taxonomy

- Two approaches from literature:

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- Two approaches from literature:
  - Use hypernym information of concepts in each cluster to determine label

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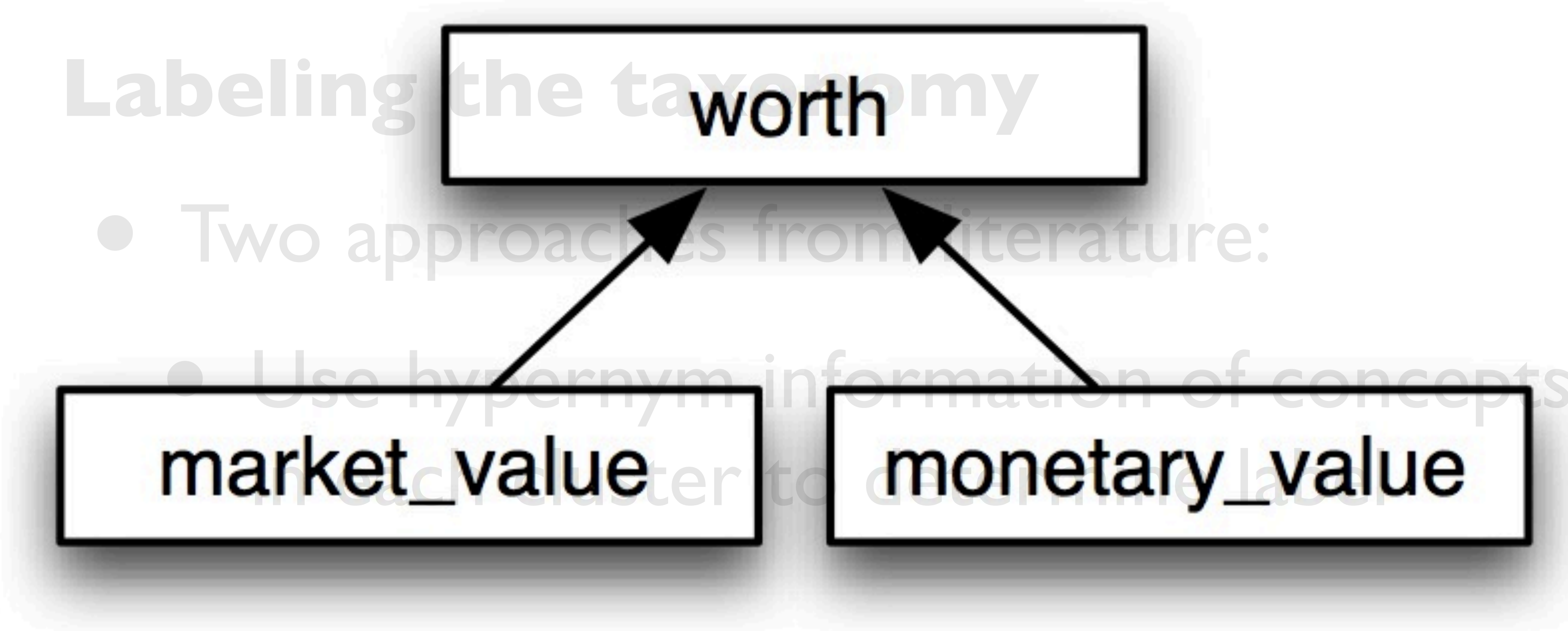

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- Two approaches from literature:
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  - Use centroid of each cluster as label

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Labeling the taxonomy

- Two approaches from literature:
  - Use hypernym information of concepts in each cluster to determine label
  - Use centroid of each cluster as label
- We employ a hybrid approach

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4. Construct and label taxonomy

Labeling the taxonomy (hybrid)

- Our hybrid approach:
  - first checks whether there is a concept that is a hypernym of *x* other concepts
  - for clusters of size 2, we use the common hypernym
  - otherwise: we use a modified version of the centroid approach

Evaluation

Several measures used to obtain the precision, recall, and F1-measure

- Lexical recall
- Taxonomy Overlap

Evaluation

Several measures used to obtain the precision, recall, and F1-measure

- Lexical recall

$$LR(O_1, O_2) := \frac{|O_1 \cap O_2|}{|O_2|}$$

- Taxonomy Overlap

Evaluation

Taxonomy Overlap

$$\overline{TO}(O_1, O_2) := \frac{1}{|O_1|} \times \sum_{c \in O_1} TO(c, O_1, O_2)$$

$$TO(c, O_1, O_2) := \begin{cases} TO^{'}(c, O_1, O_2), & c \in O_2 \\ TO^{''}(c, O_1, O_2), & c \notin O_2 \end{cases}$$

$$TO^{'}(c, O_1, O_2) := \frac{|SC(c, O_1) \cap SC(c, O_2)|}{|SC(c, O_1) \cup SC(c, O_2)|}$$

$$TO^{''}(c, O_1, O_2) := max_{c' \in O_2} \frac{|SC(c, O_1) \cap SC(c', O_2)|}{|SC(c, O_1) \cup SC(c', O_2)|}$$

Evaluation

$$Precision : P(O_1, O_2) := \overline{TO}(O_1, O_2)$$

$$Recall : R(O_1, O_2) := \overline{TO}(O_2, O_1)$$

$$F{-}Measure :$$

$$F(O_1, O_2) := \frac{2 \times P(O_1, O_2) \times R(O_1, O_2)}{P(O_1, O_2) + R(O_1, O_2)}$$

$$F'(O_1, O_2) := \frac{2 \times LR(O_1, O_2) \times F(O_1, O_2)}{LR(O_1, O_2) + F(O_1, O_2)}$$

Evaluation

- Data set from Erasmus RePub repository
  - consists of 236 papers in the domain of Financial Economics
  - abstracts of papers in medicine & health, law, and culture & society were also used
- Manually constructed golden taxonomy
  - using WordNet synsets
  - only utilizing knowledge from the data set

Evaluation

Measure	**WordNet**	**Web**	**PMI**
Lexical recall	0.42	0.43	0.44
Precision	0.50	0.99	0.69
Recall	0.27	0.19	0.21
F-measure	0.35	0.32	0.32
F’-measure	0.38	0.37	0.37

Questions?