



The Knowledge Graph Conference

Causal Knowledge Graph (KG)- Infused Prescriptive Analytics

2022 Knowledge Graph Conference, May 6th

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Director of Data Analytics and Insights, Experimental Design and Causal Inference

Fidelity Investments

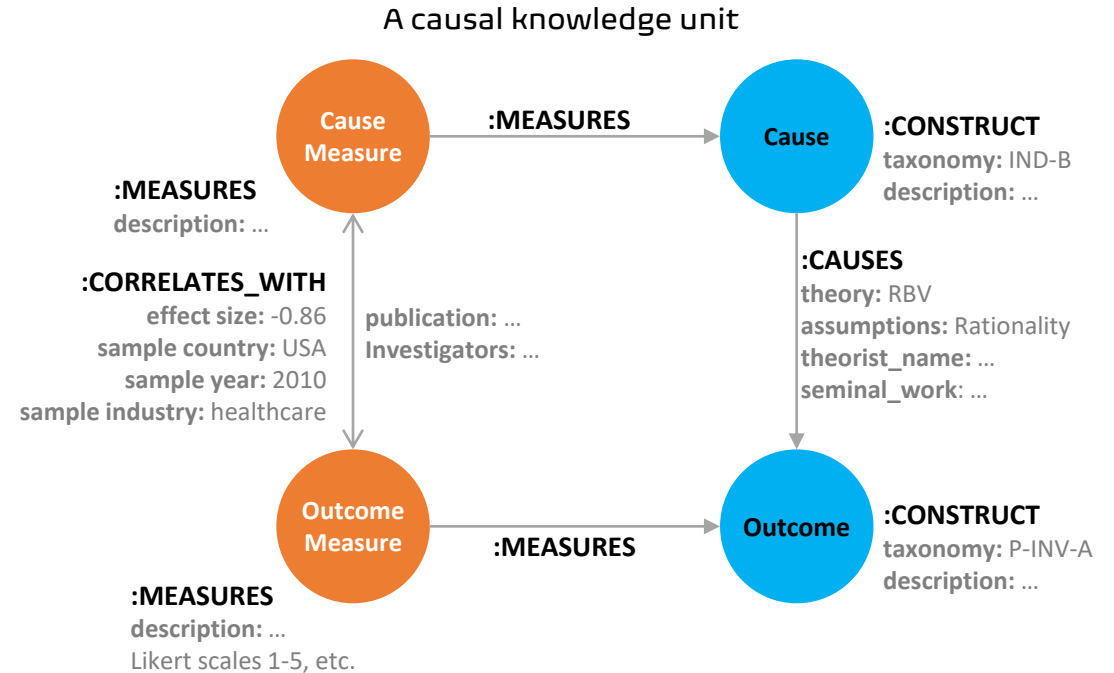
Agenda

- 1. What is causal knowledge graph (KG)?
- 2. How to construct a causal KG?
- 3. How to infuse a causal KG into data analytics?

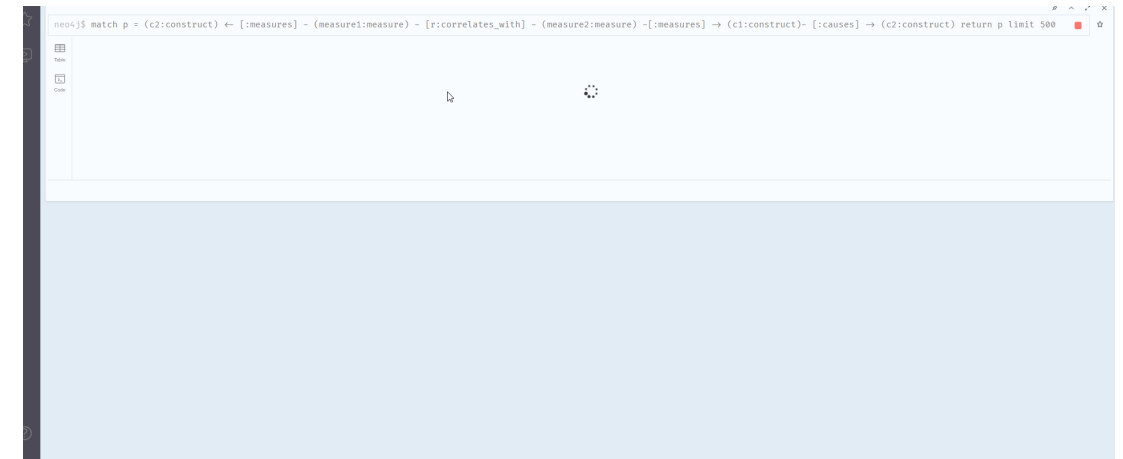
1. What is a Causal KG?

A unified and cumulative representation of knowledge

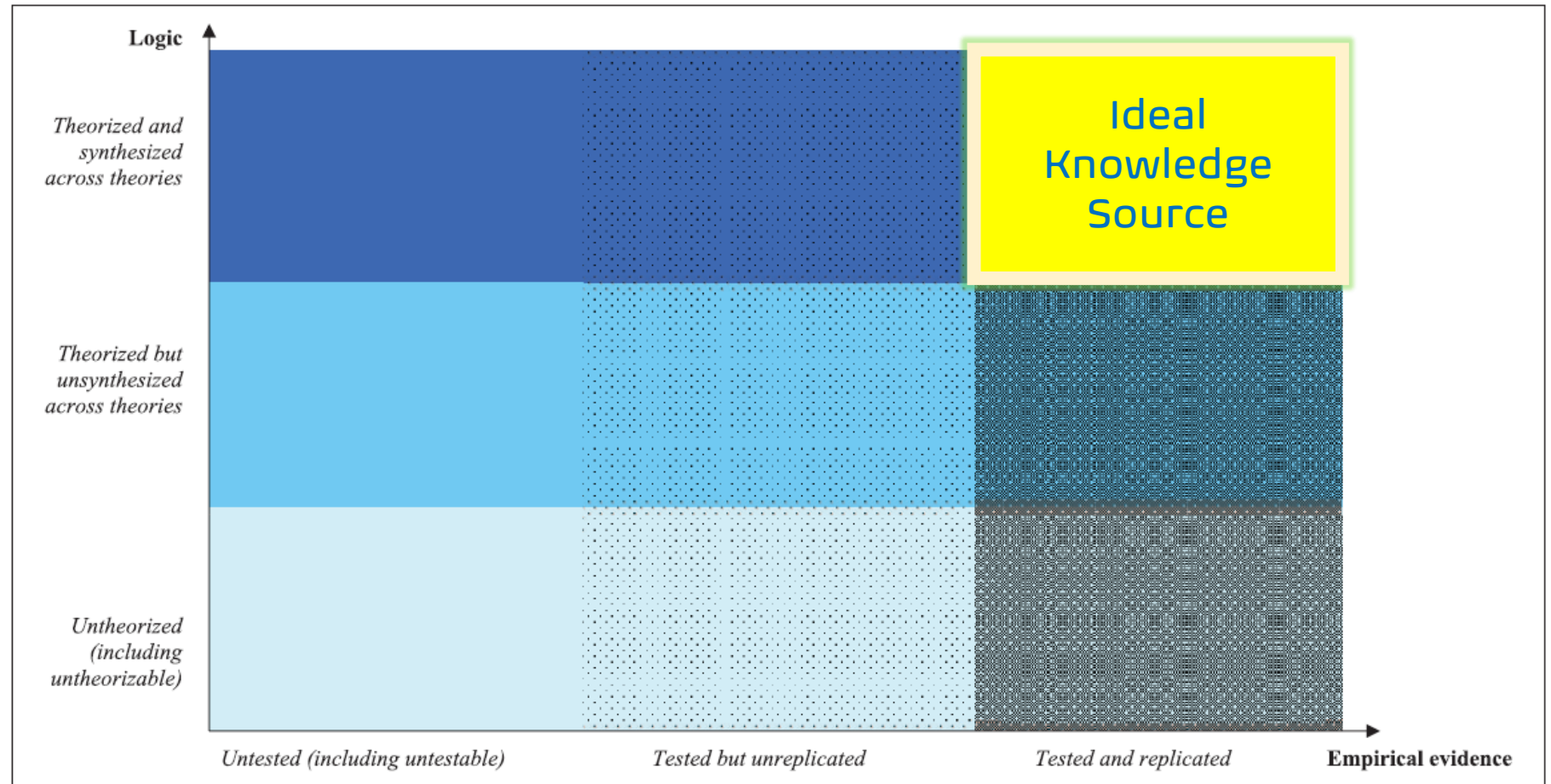
- Entities (e.g., constructs and variables)
- Directed Links:
 - Ontological relationships (e.g., taxonomy, semantics)
 - Causal logic (e.g., common sense, theoretical hypothesis, expert assumptions)
 - Prior empirical evidence (e.g., experiments and Bayesian meta-analysis)



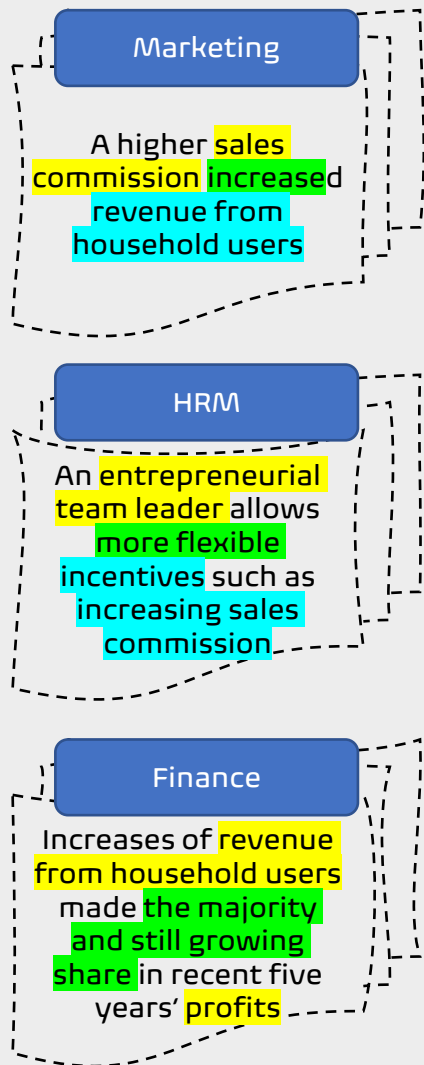
A causal KG database



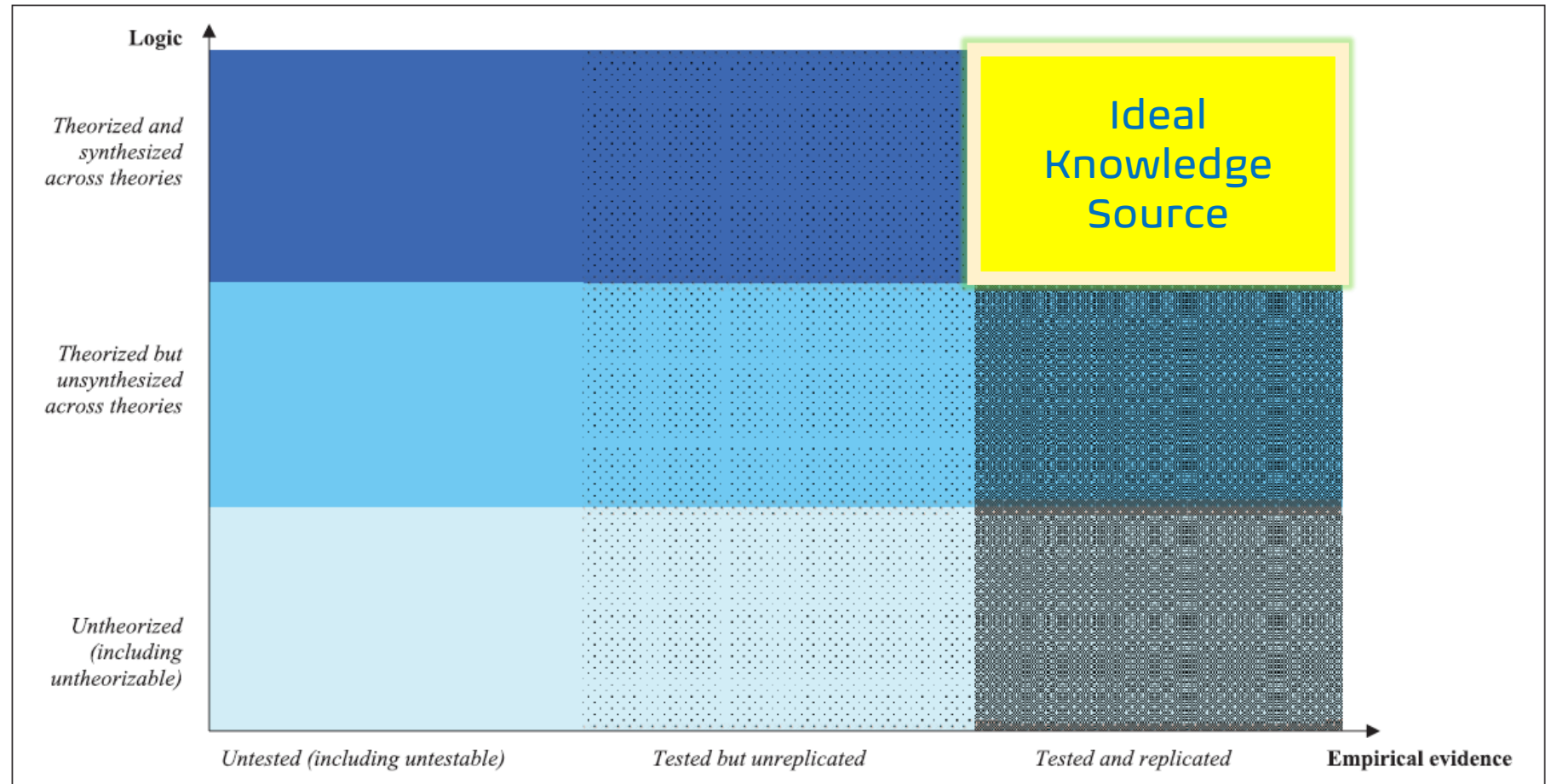
2. How to construct a Causal KG?



Source: Chen and Hitt (2021)



2. How to construct a Causal KG?



Source: Chen and Hitt (2021)

Sourcing

Marketing

A higher sales commission increased revenue from household users

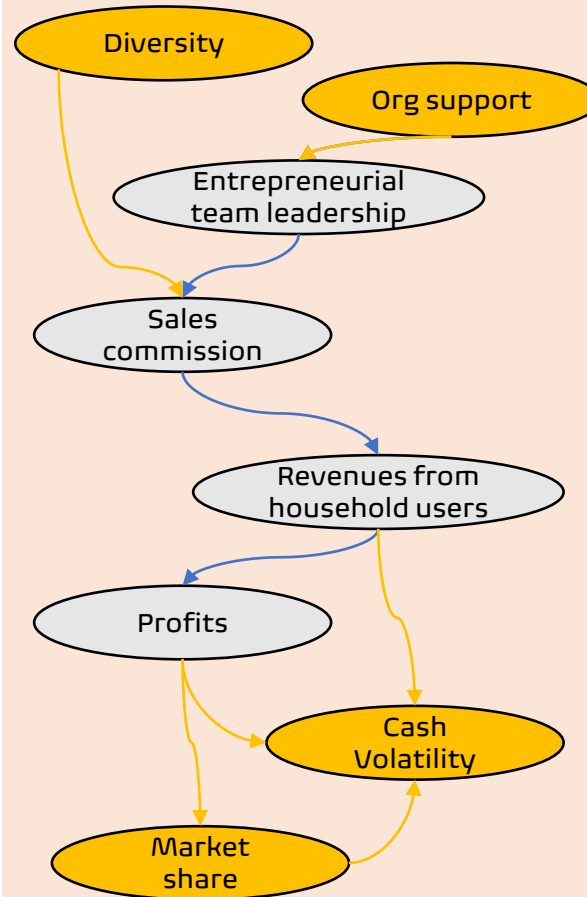
HRM

An entrepreneurial team leader allows more flexible incentives such as increasing sales commission

Finance

Increases of revenue from household users made the majority and still growing share in recent five years' profits

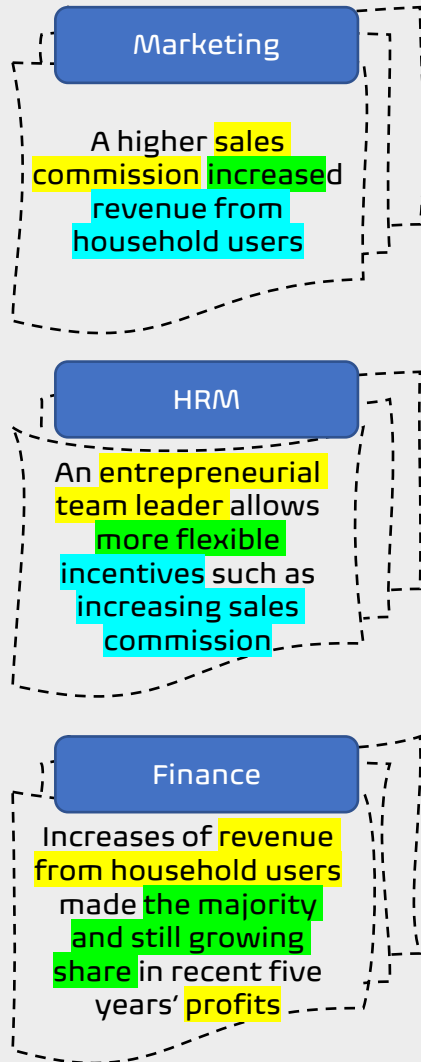
Graphing



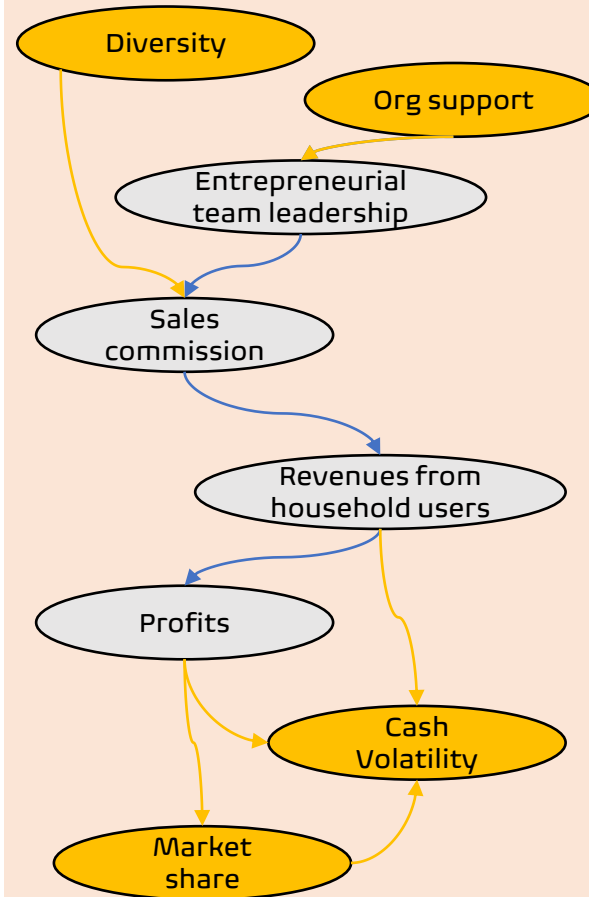
Synthesis

Analysis

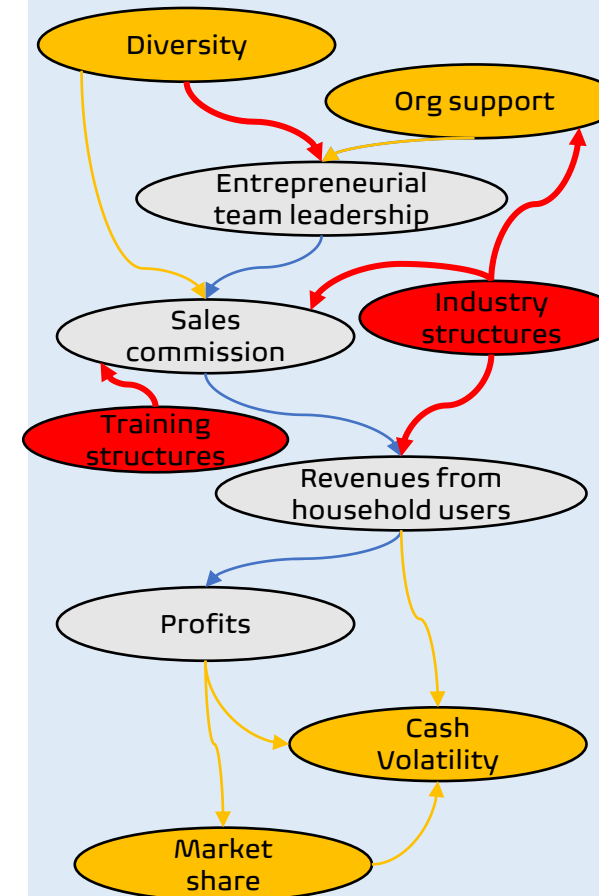
Sourcing



Graphing

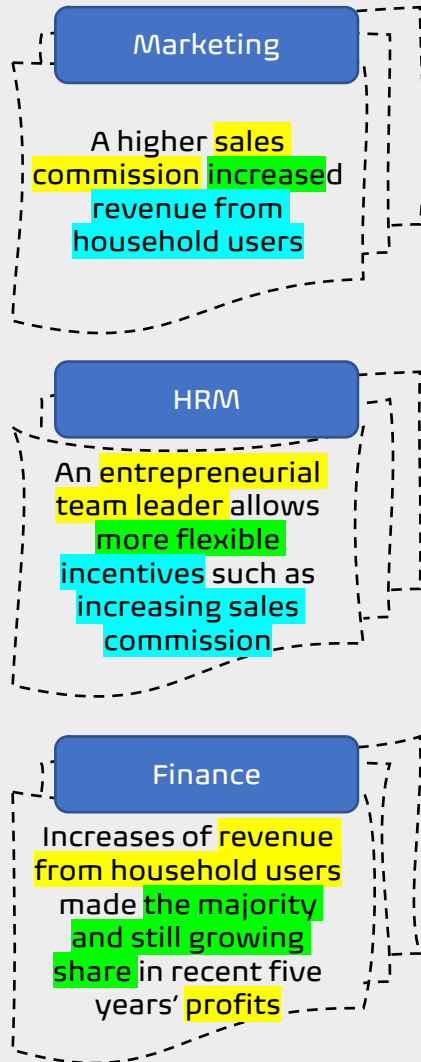


Synthesis

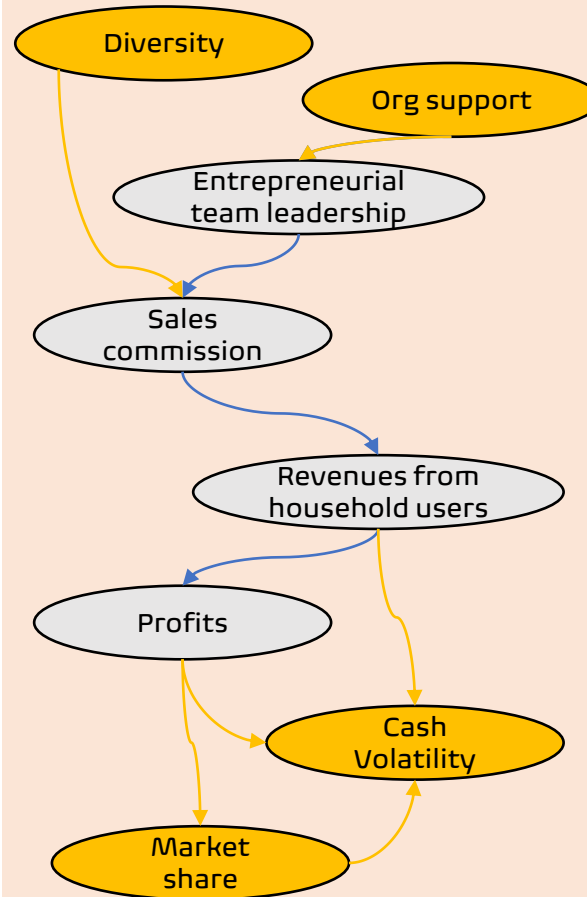


Analysis

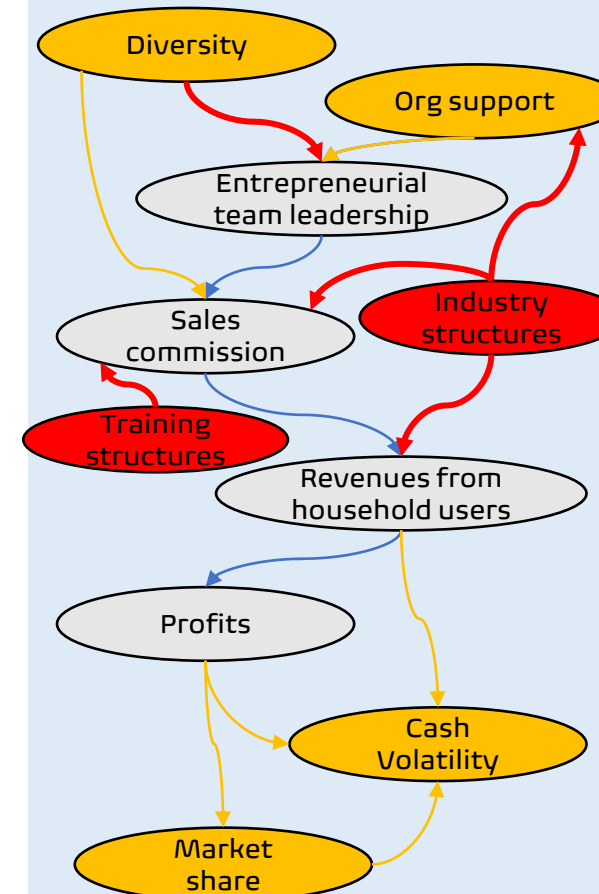
Sourcing



Graphing

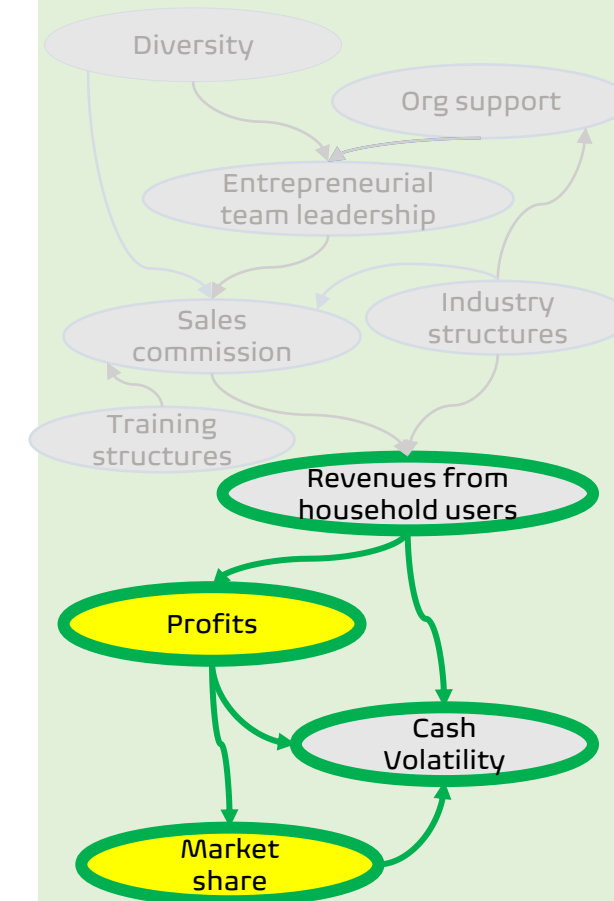


Synthesis



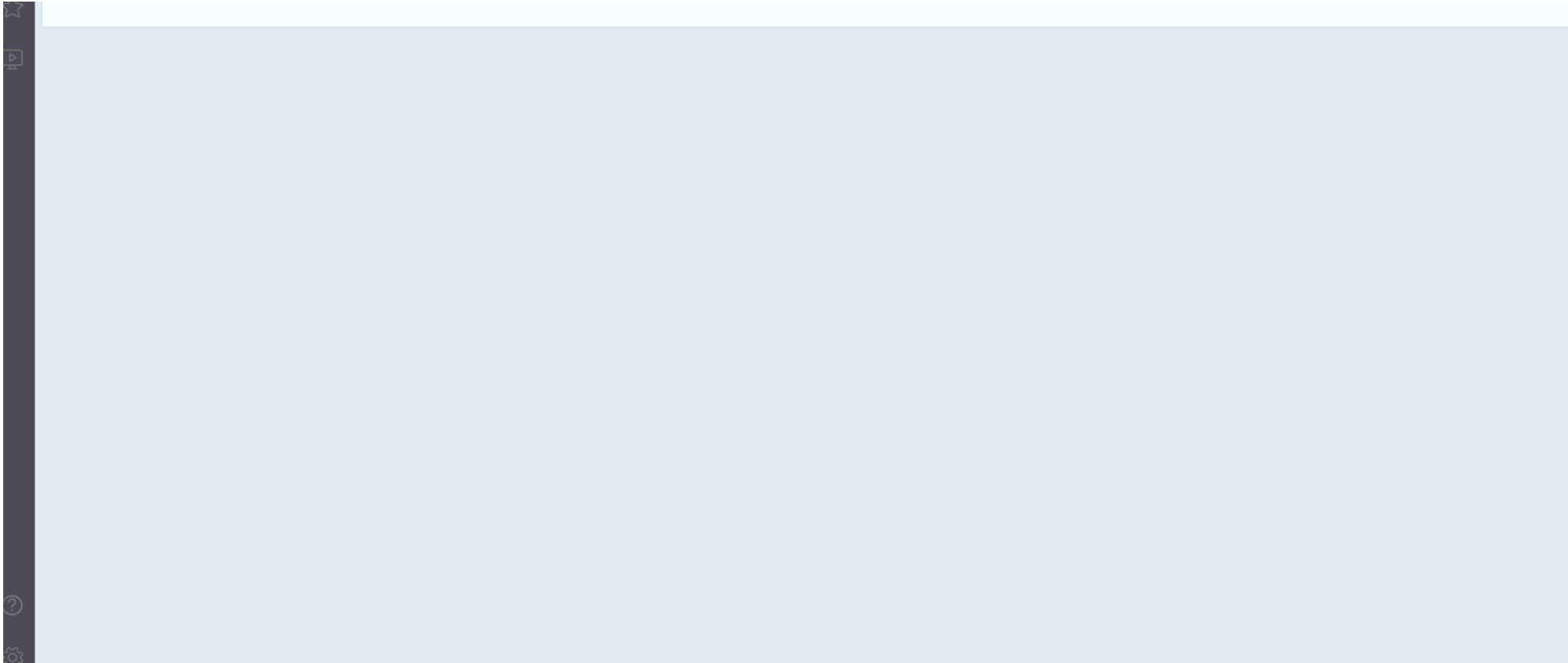
Analysis

Causal Graph-based Data Science



2. How to construct a Causal KG?

Step 1. Constructing and loading a unified taxonomy



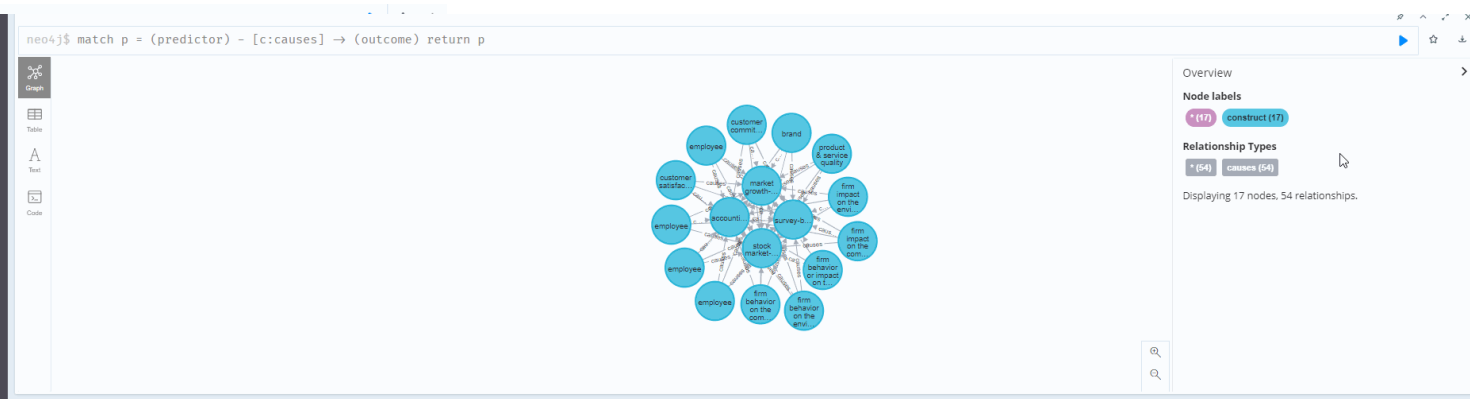
2. How to construct a Causal KG?

Step 2. Adding theoretical/causal assertions

```
neo4j$ match p = (predictor) - [c:causes] -> (outcome) return predictor.name, outcome.name, c.theory
```

| | predictor.name | outcome.name |
|---|------------------------------------|--------------------------------------|
| 1 | "firm behavior on the community" | "stock market-based performance" |
| 2 | "firm behavior on the community" | "survey-based financial performance" |
| 3 | "firm behavior on the community" | "market growth-based performance" |
| 4 | "firm behavior on the community" | "accounting-based performance" |
| 5 | "firm behavior on the environment" | "accounting-based performance" |
| 6 | "firm behavior on the environment" | "market growth-based performance" |

Started streaming 54 records in less than 1 ms and completed after 3 ms.



2. How to construct a Causal KG?

Step 3. Linking constructs with measures/variables

```
neo4j$ match p = (measure:measure) -[:measures] - (construct:construct) return construct.name, measure.name, measure.description
```

| | construct.name | measure.name | measure.description |
|---|----------------------------------|------------------------------|--|
| 1 | "firm behavior on the community" | "social performance" | "We conduct one of only very few studies of the antecedents of corporate reputation drawing on a multivariate data set that describes the financial performance, social performance, size, R&D and advertising intensity, and industry of sample companies." |
| 2 | "firm behavior on the community" | "soccdis" | "Level of corporate social responsibility disclosure for firm i in period t: 0 = poor, 1 = good, 2 = excellent" |
| 3 | "firm behavior on the community" | "csr" | "We used the 13-item scale developed by Singhapakdi, Vitell, Rallapalli, and Kraft (1996) to measure the perceptions of top management toward CSR (ranging from 1 = totally disagree, to 5 = totally agree; sample items include "Social responsibility and profitability can be compatible," "Being ethical and socially responsible is the most important thing a firm can do," and "Business has a social responsibility")" |
| 4 | "firm behavior on the community" | "csr" | "We define CSR as those business activities that take into account the interests of society" |
| 5 | "firm behavior on the community" | "government-aimed csr" | "On operational terms, global retailers donate cash or provide services to communities" |
| 6 | "firm behavior on the community" | "community responsibilities" | "Give money to charities in the communities where we operate" |

Started streaming 1116 records after 1 ms and completed after 2 ms, displaying first 1000 rows.

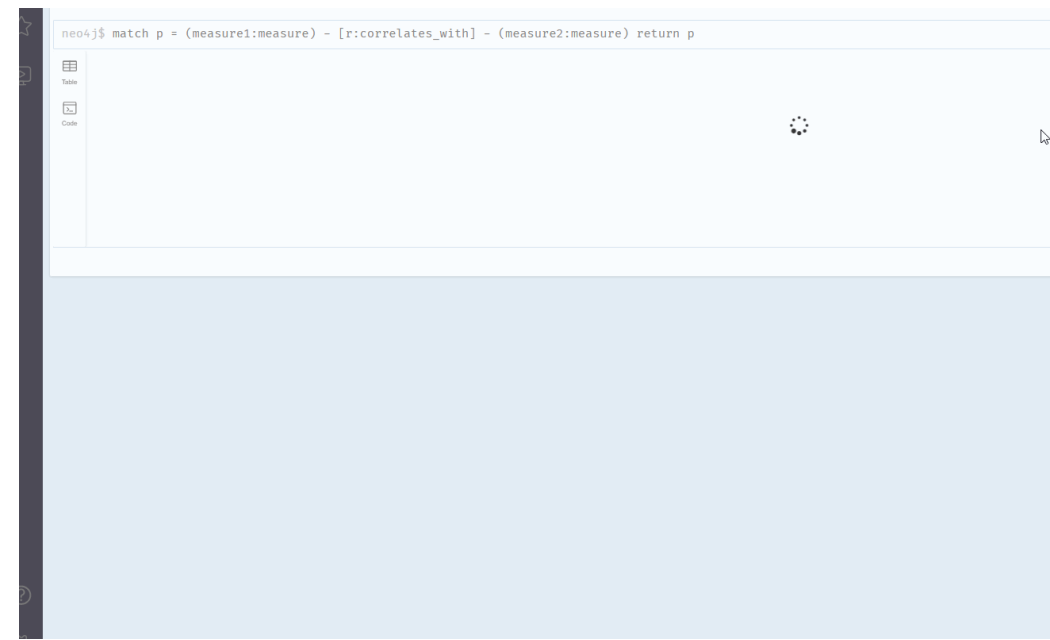
```
neo4j$ match p = (measure:measure) -[:measures] - (construct:construct) return p
```

| "p" |
|---|
| [{"name": "social performance", "description": "We conduct one of only very few studies of the antecedents of corporate reputation drawing on a multivariate data set that describes the financial performance, social performance, size, R&D and advertising intensity, and industry of sample companies.", "name_raw": "Social performance", "level1": "firm behavior on the community", "description": "the actions a firm has taken or reported on the community (with impact unknown)", "level1": "community benefits", "level0": "organizational performance"}] |
| [{"name": "soccdis", "description": "Level of corporate social responsibility disclosure for firm i in period t: 0 = poor, 1 = good, 2 = excellent", "name_raw": "SOCODIS", "level1": "firm behavior on the community", "description": "the actions a firm has taken or reported on the community (with impact unknown)", "level1": "community benefits", "level0": "organizational performance"}] |
| [{"name": "csr", "description": "We used the 13-item scale developed by Singhapakdi, Vitell, Rallapalli, and Kraft (1996) to measure the perceptions of top management toward CSR (ranging from 1 = totally disagree, to 5 = totally agree; sample items include \"Social responsibility and profitability can be compatible,\" \"Being ethical and socially responsible is the most important thing a firm can do,\" and \"Business has a social responsibility\")", "name_raw": "CSR", "level1": "firm behavior on the community", "description": "the actions a firm has taken or reported on the community (with impact unknown)", "level1": "community benefits", "level0": "organizational performance"}] |

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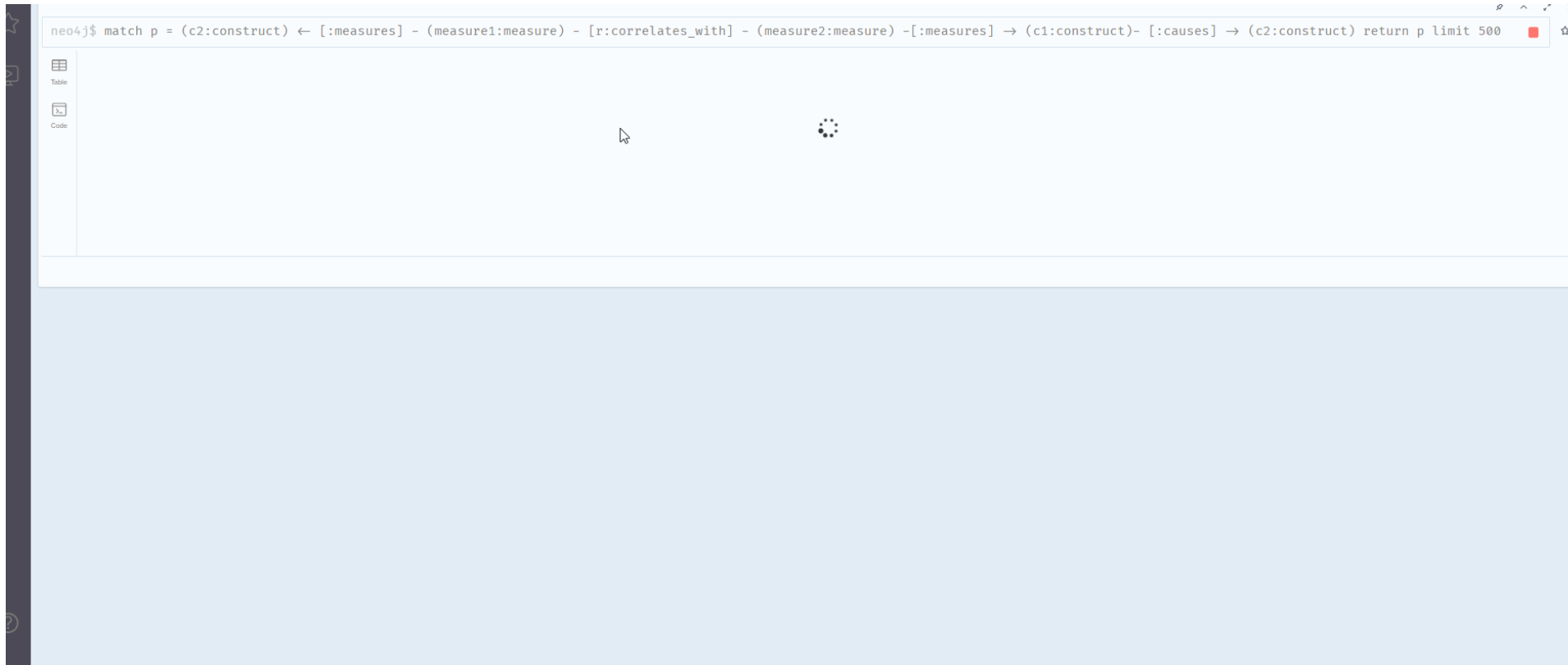
2. How to construct a Causal KG?

Step 4. Adding statistical evidence and sample meta data

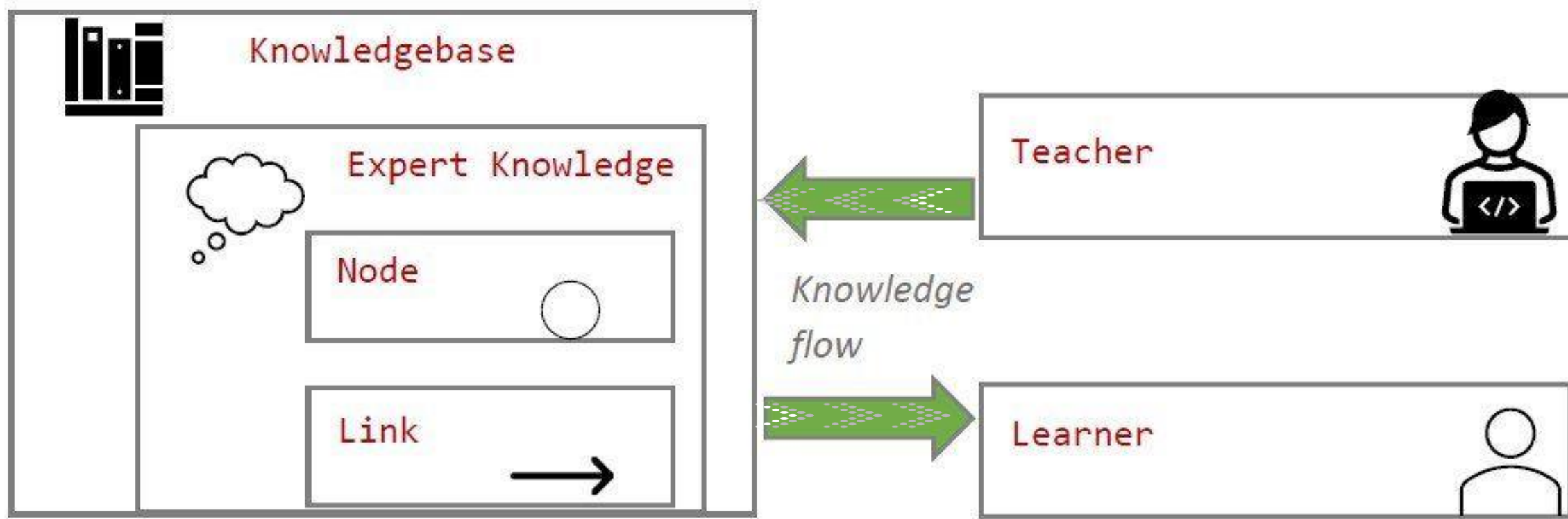


2. How to construct a Causal KG?

Here you go! A complete causal knowledge graph

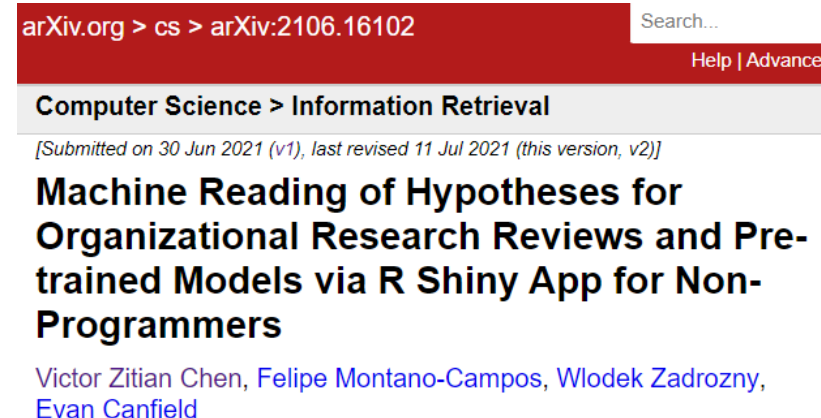
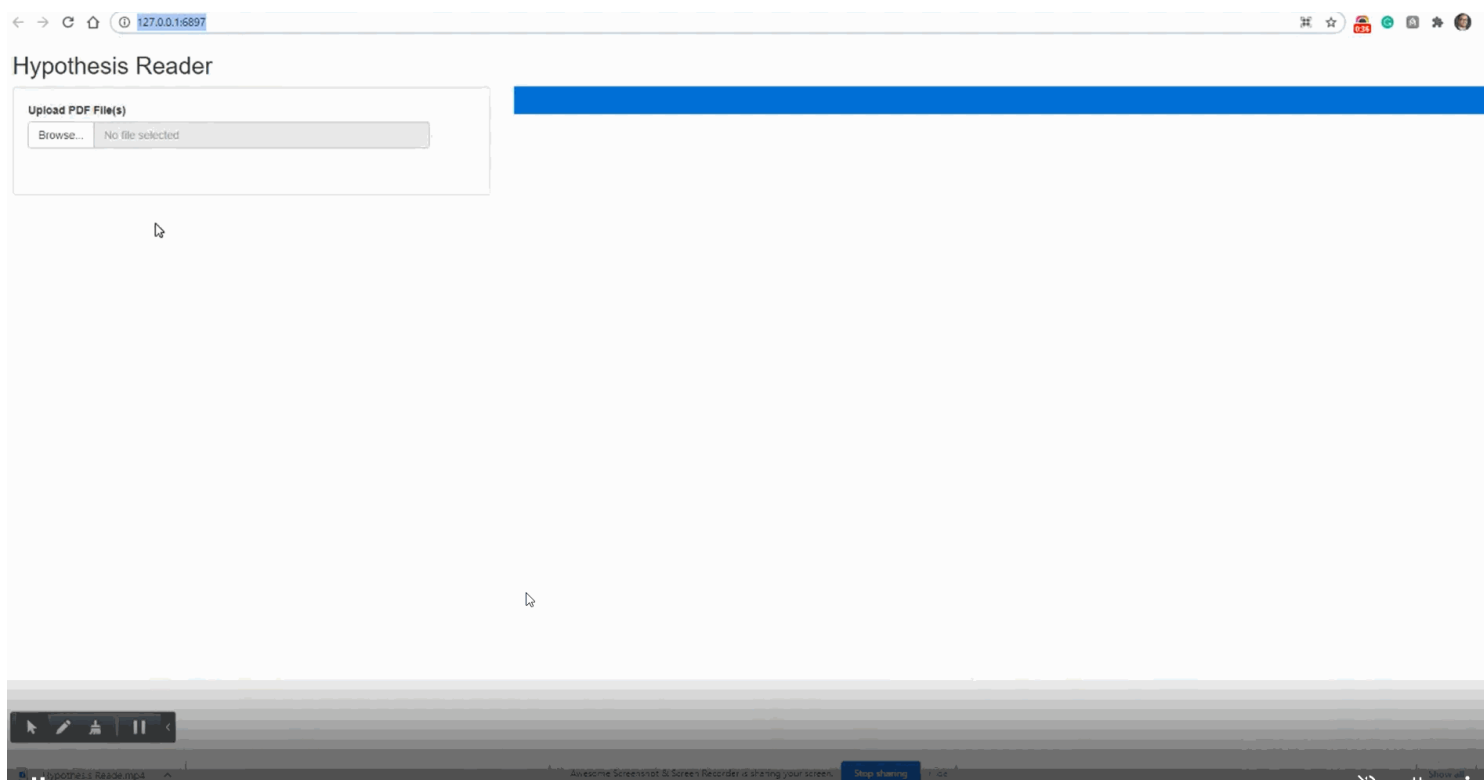


2. How to construct a Causal KG? An Expert Community Approach



2. How to construct a Causal KG? A Machine Learning Approach

1. Machine Reading of Hypotheses



2. How to construct a Causal KG? A Machine Learning Approach

2. Entity Classification

| | Model | P | R | F1 |
|---------------------|--------------------------|------|------|------|
| Engineered features | XGBoost | 0.74 | 0.71 | 0.72 |
| | Multinomial naïve Bayes | 0.80 | 0.81 | 0.80 |
| | SVM | 0.81 | 0.81 | 0.81 |
| | Logistic regression | 0.81 | 0.81 | 0.81 |
| Latent features | FastText | 0.84 | 0.79 | 0.81 |
| | Fine-tuned BERT | 0.59 | 0.51 | 0.40 |
| | SpaCy embeddings with LR | 0.74 | 0.75 | 0.75 |
| | Elmo embeddings with LR | 0.78 | 0.78 | 0.78 |

arXiv.org > cs > arXiv:2107.05133

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Help | Advanced Search

Computer Science > Computation and Language

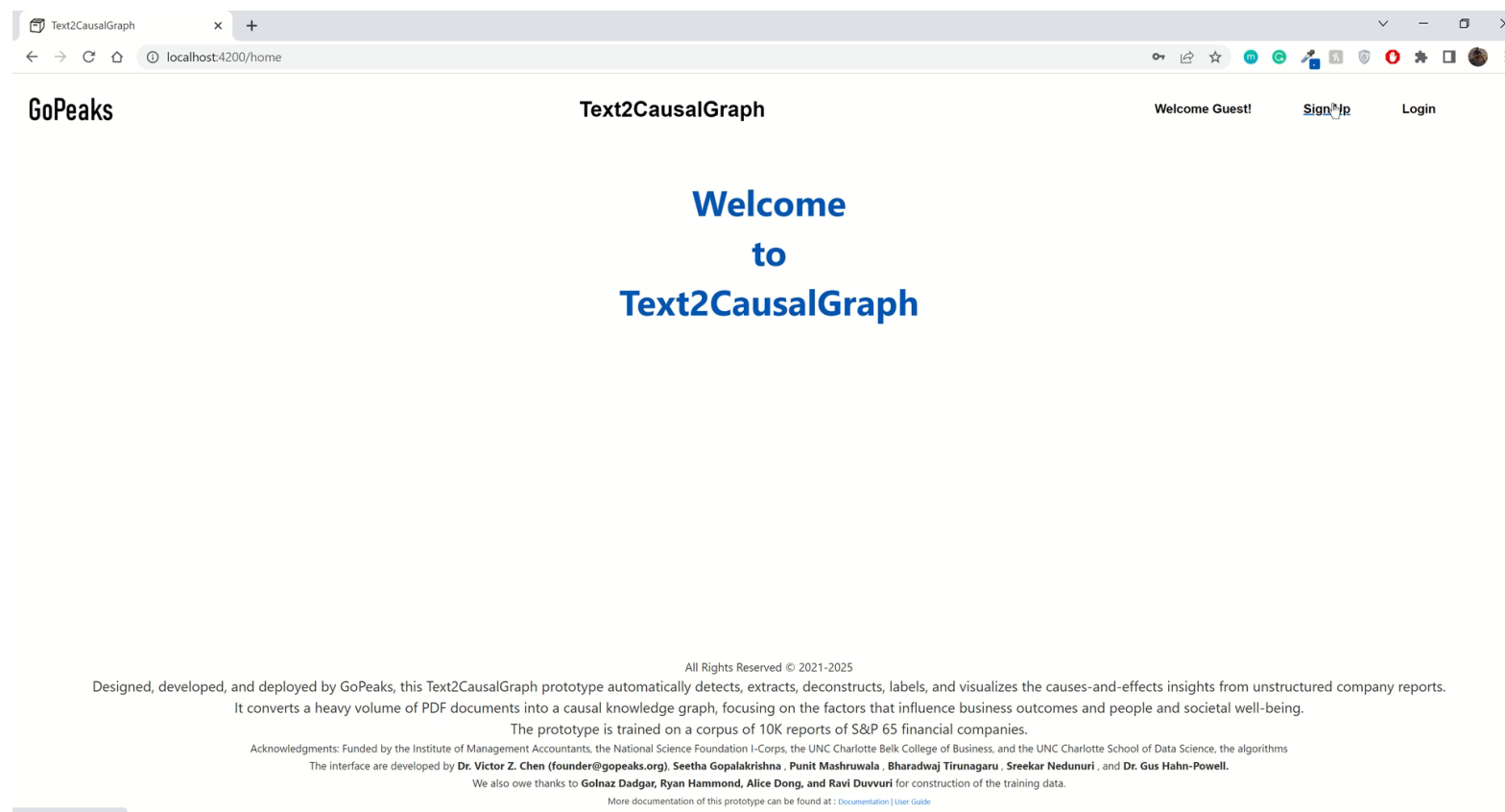
[Submitted on 11 Jul 2021 (v1), last revised 24 Aug 2021 (this version, v2)]

Computer-assisted construct classification of organizational performance concerning different stakeholder groups

Seethalakshmi Gopalakrishnan, Victor Chen, Gus Hahn-Powell, Bharadwaj Tirunagar

2. How to construct a Causal KG? A Machine Learning Approach

3. Converting Text into KG Database

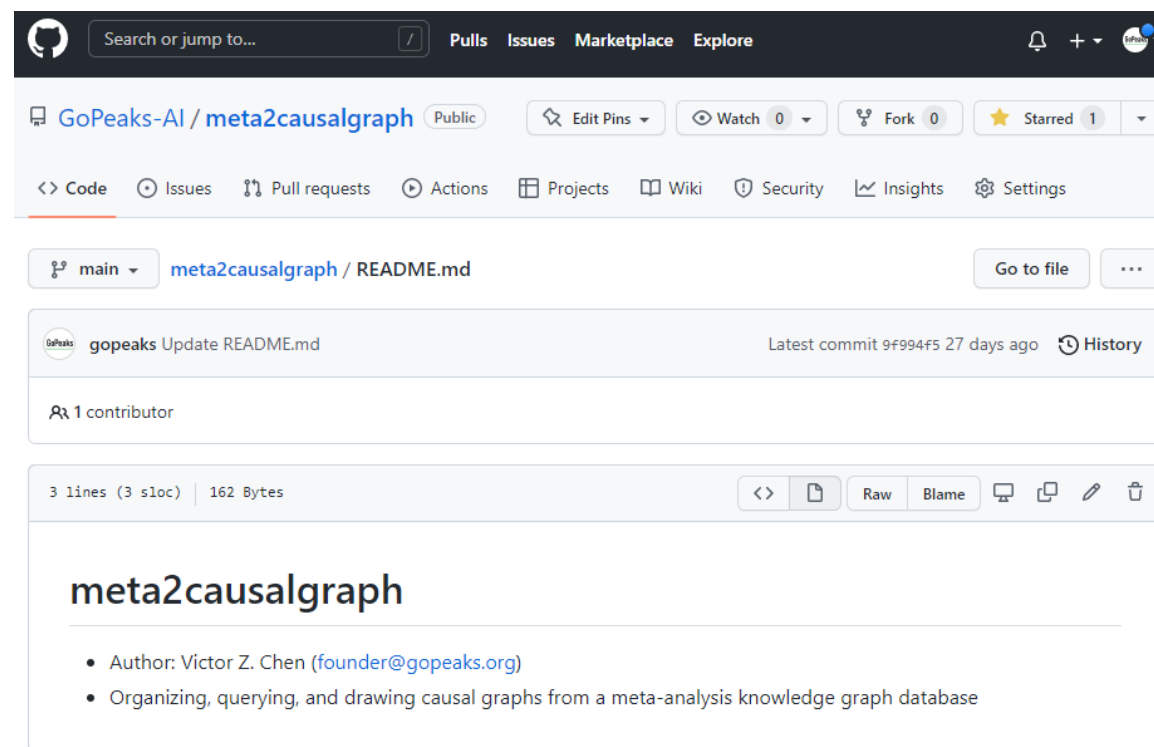


Disclaimer: This talk does not represent the view of Fidelity Investments. It is based on my previous research at GoPeaks, funded by the National Science Foundation and the Institute of Management Accountants. Please visit www.GoPeaks.org for more information and readings.

2. How to construct a Causal KG?

A demonstration using Python and Neo4j

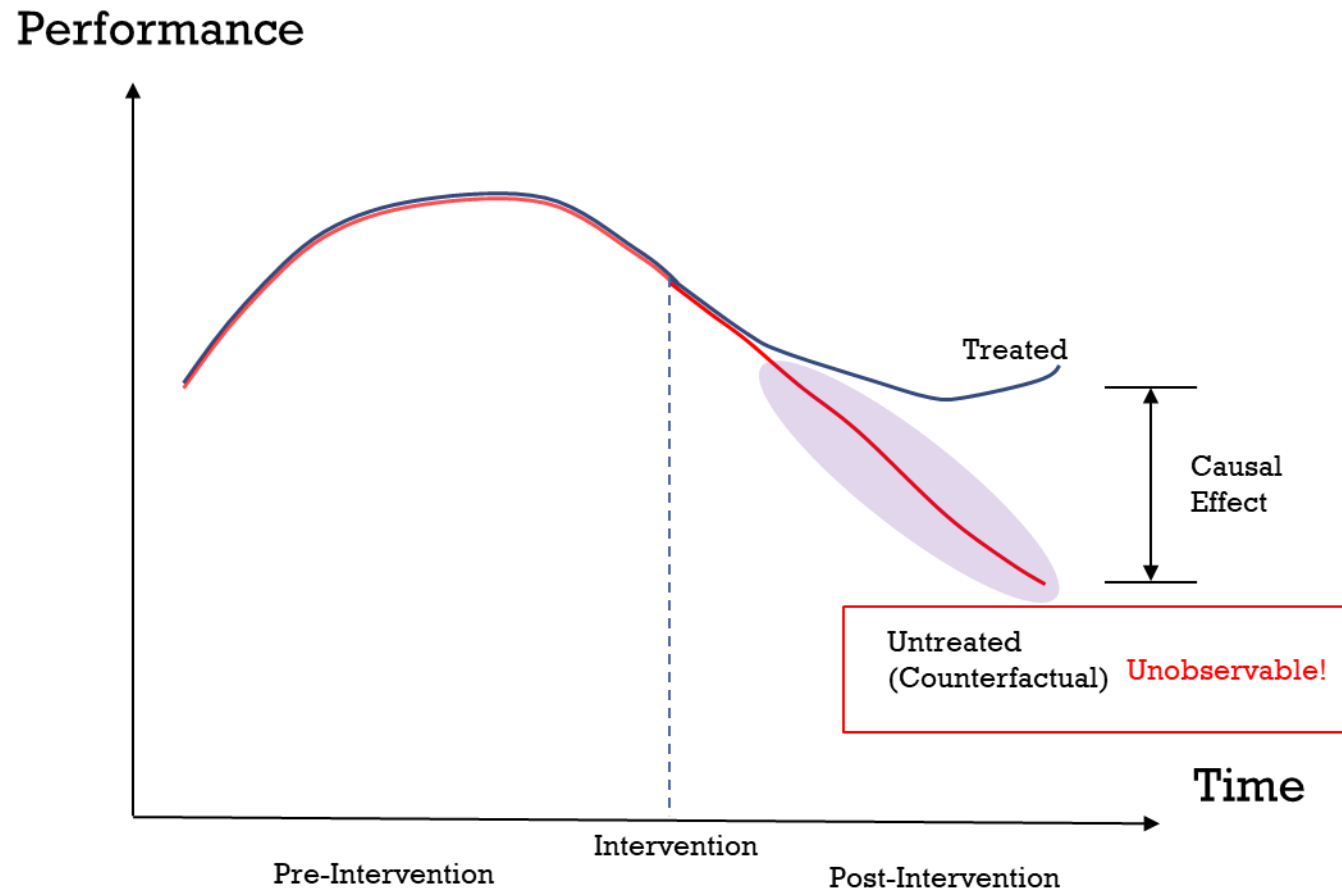
<https://github.com/GoPeaks-AI/meta2causalgraph>



3. How to infuse Causal KG into prescriptive analytics?

The essence of causal analysis:

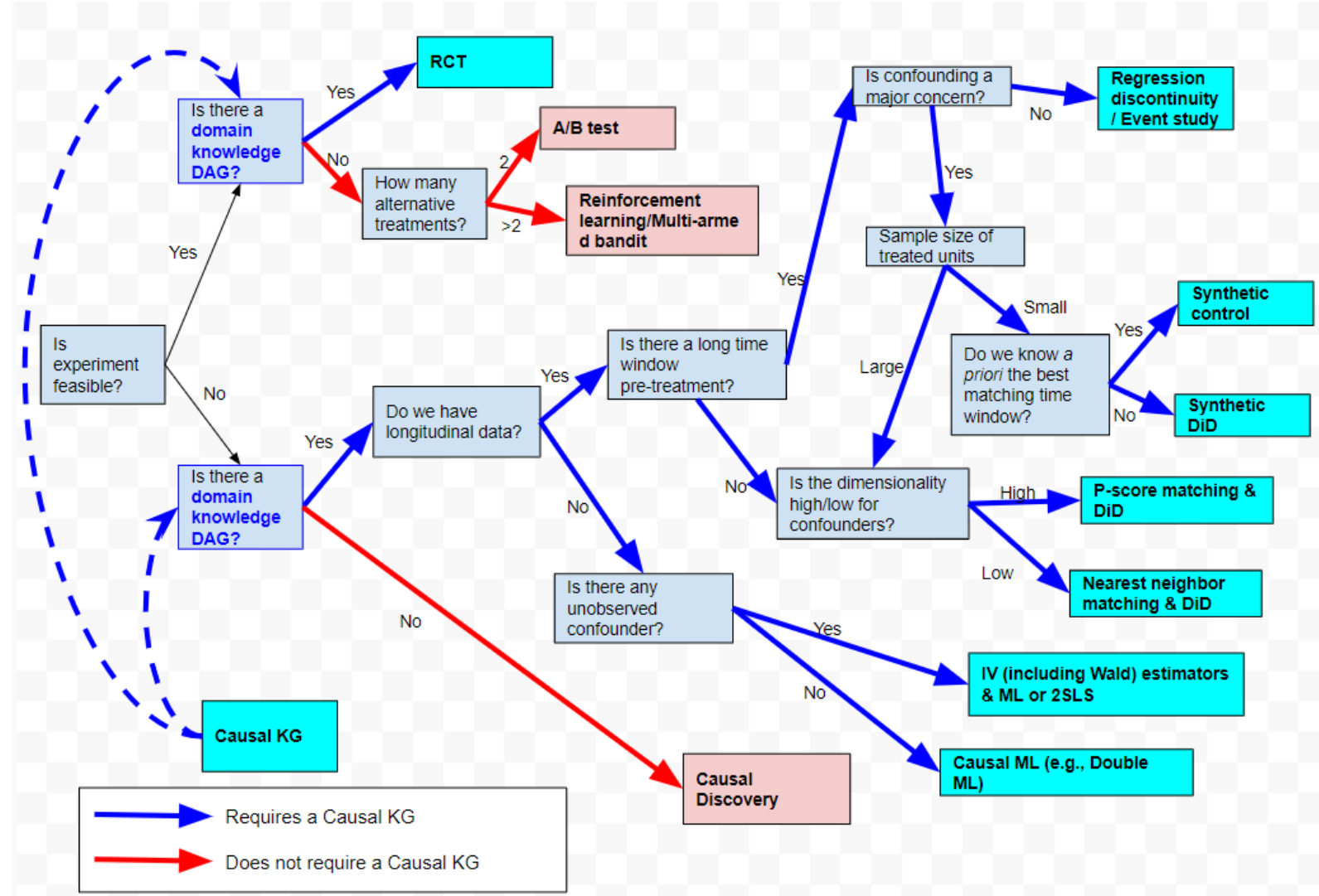
- Self-counterfactual comparison
 - Balancing: Similar distribution in covariates
 - Debiasing: Removing the confounding



3. How to infuse Causal KG into prescriptive analytics?

Causal KG may enable and improve many causal analytics methods by:

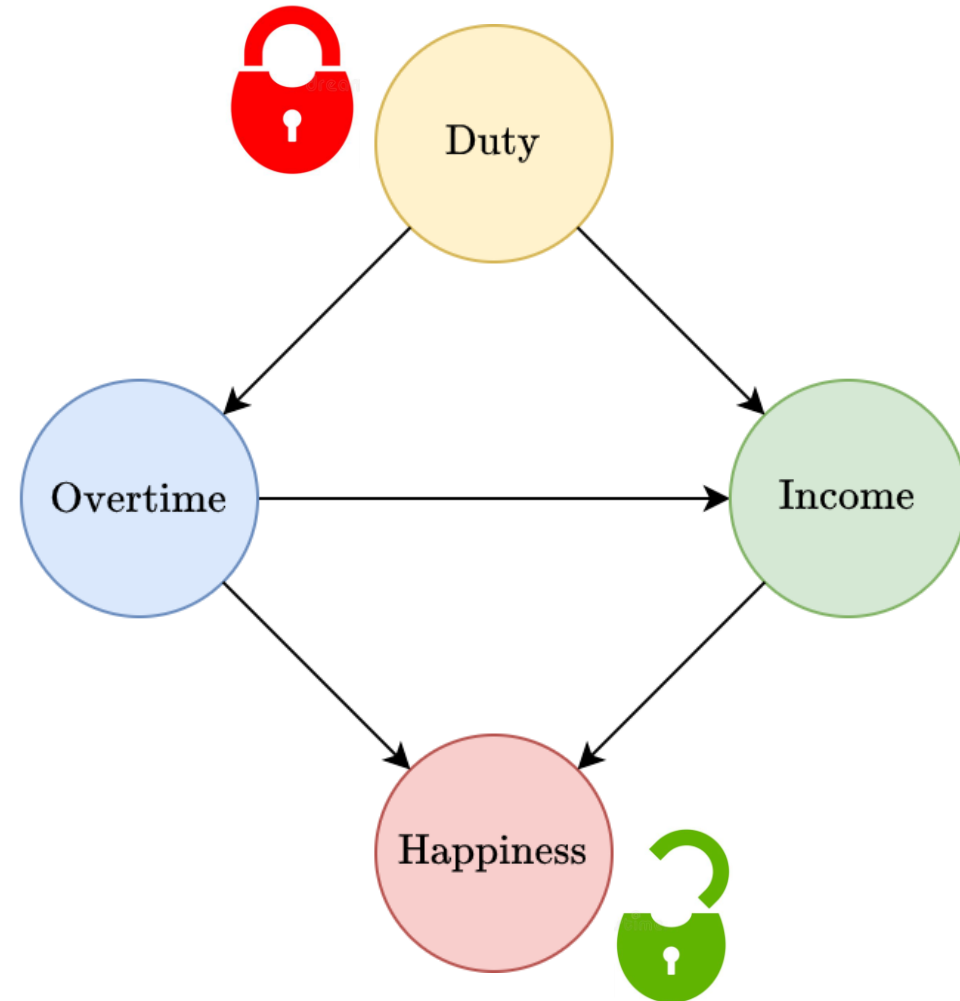
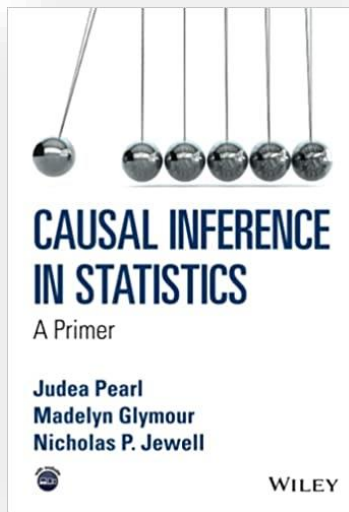
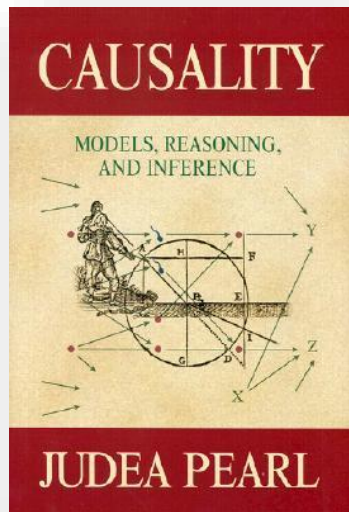
- Identifying what covariates need to be balanced
- Identifying what confounding biases there are in observational data



3. How to infuse Causal KG into prescriptive analytics?

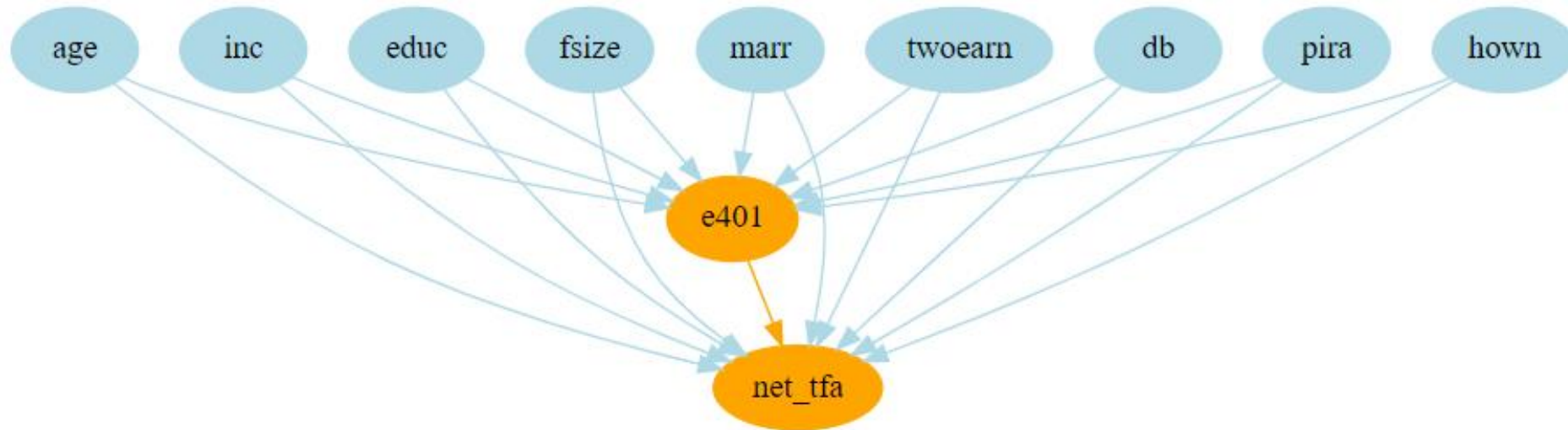
Theory: Do Calculus

e.g., back-door closing, front-door opening, no unobserved confounders, etc.



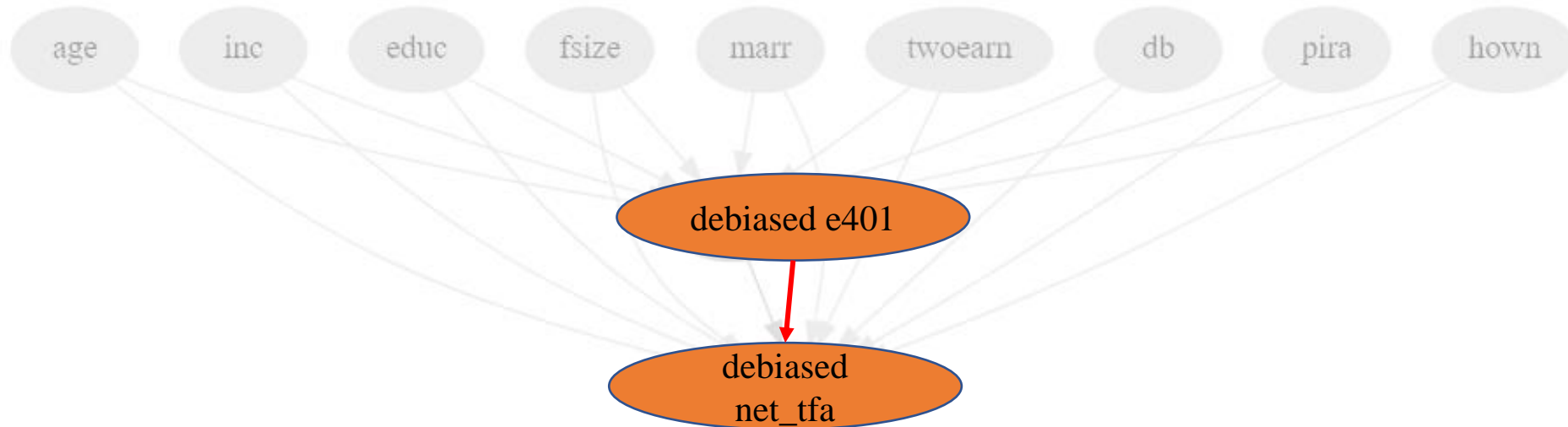
3. How to infuse Causal KG into prescriptive analytics?

A demonstration using Jupyter Notebook and Neo4j



3. How to infuse Causal KG into prescriptive analytics?

A demonstration using Jupyter Notebook and Neo4j



Want to learn more?



GoPeaks.org



github.com/GoPeaks-AI

towards
data science

@victorzitianchen