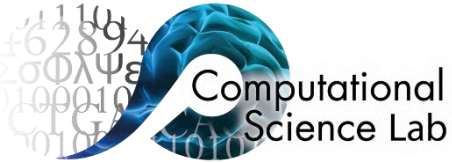
KPMG

Computational Science Lab

Complex networks in audit

A data-driven modelling approach

With you today



Marcel Boersma PhD

Computational Science Lab
and AI4FinTech

Senior Manager at KPMG

Introduction

Agenda

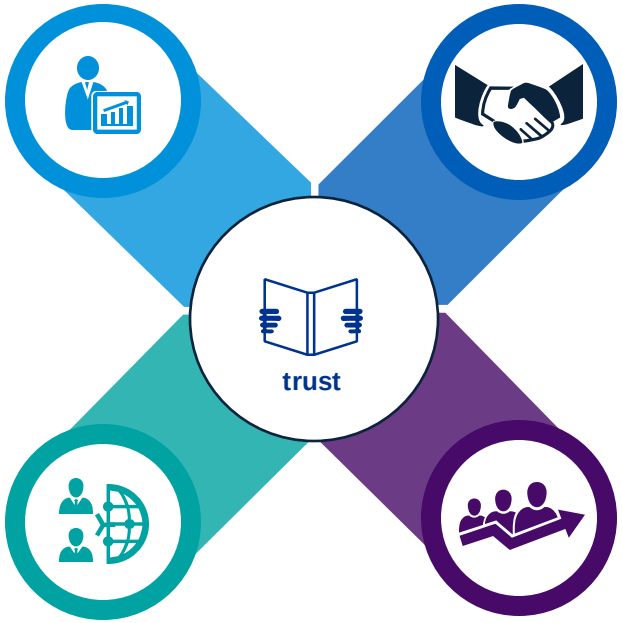
- Introduction to auditing and financial information
- A network model for auditing
- Network statistics
- Network coarsegraining
- Network similarity

Introduction

Financial information

01 Investors

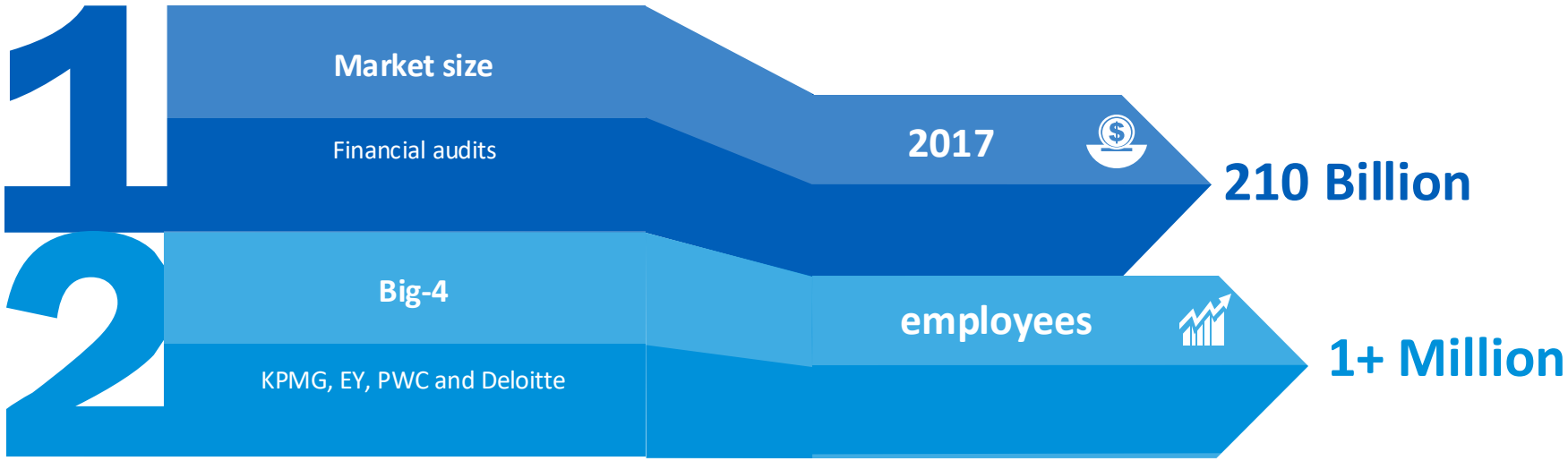
02 Lendors



03 Creditors

04 Governments

Audit industry



- **Source:**
- https://www.thebusinessresearchcompany.com/report/auditing-services-global-market-report-2018
- https://www.pwc.com/gx/en/about/global-annual-review-2019.html
- https://www2.deloitte.com/global/en/pages/about-deloitte/articles/global-report-home.html
- https://home.kpmg/xx/en/home/campaigns/2018/12/global-review.html
- https://www.ey.com/en_gl/global-review/2018

What is an audit?

Annual statement

True and fair representation

Performance and developments — The public trusts us — KPMG

Internal inspections (Quality Performance Reviews or QPR)

QPR is performed under the supervision of the Compliance Office with a team of Dutch (local) and non-Dutch (non-local) reviewers at partner and senior-manager level. Engagements are rated against KPMG's global quality baselines. These baselines and ratings differ between Audit and Advisory. Audit engagements reviewed are rated Satisfactory, Performance Improvement Necessary or Unsatisfactory depending on the nature and severity of findings. Advisory engagements reviewed receive two ratings – one for set up and one for execution. Ratings are Green, Yellow or Red. Green and Yellow ratings are awarded when engagements are substantially compliant with KPMG standards. The QPR process is overseen by a non-local lead reviewer. A centrally led international Quality Performance Review team carries out a number of the annual QPR reviews at various KPMG member firms, especially for audits of listed and related entities.

During the year under review, 59 Audit partners (FY 2016/17: 52) and 55 Advisory partners/directors (FY 2016/17: 72) were subject to internal quality performance reviews.

Audit

In Audit 68% of the engagements received a Satisfactory rating (FY 2016/17: 65%). Although our target of 75% Satisfactory scores was not yet achieved, we have made significant progress on decreasing the number of less than satisfactory scores. We launched a quality coaching effort on auditing of revenue (one

QPR Audit

FY2018: 11, 32, 21, 68 — FY2017: 16, 35, 19, 65

Satisfactory
Less then satisfactory
Performance Improvement Necessary
Unsatisfactory

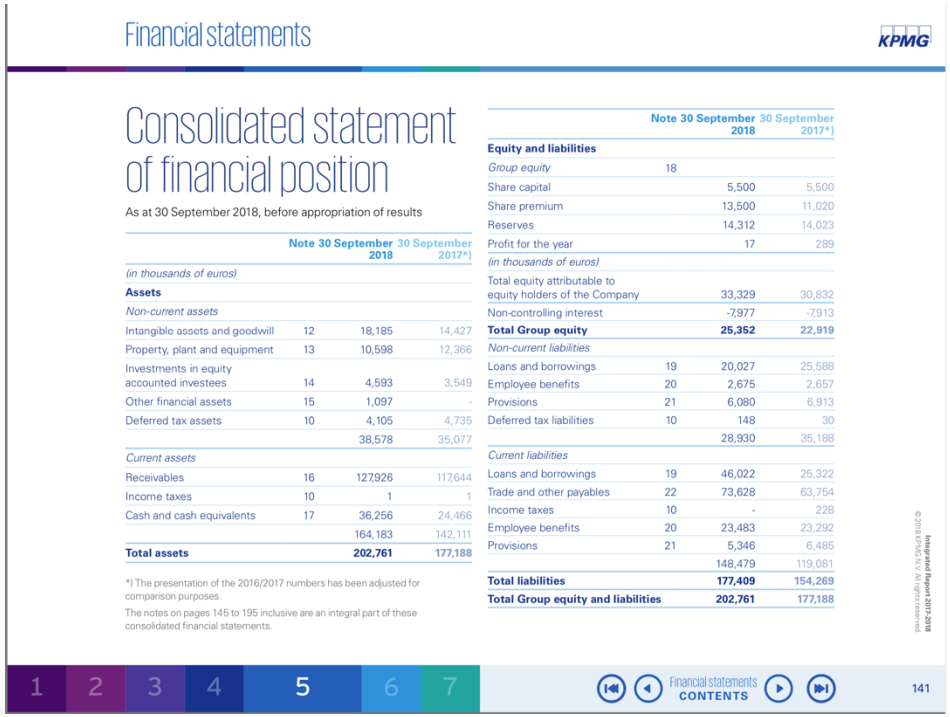
Figure 2. QPR scores Audit partners/directors

of the most common areas with QPR findings) to help engagement teams real-time rather than after the fact. We saw a decrease in revenue related findings indicating that team coaching appears to be a driver for audit quality. We will test this hypothesis next year by expanding this type of quality coaching to other areas with QPR findings.

In general, employees are satisfied with daily training on the job with 87% positive scores in the annual Global People Survey.

QPR findings have been communicated to Audit professionals during KPMG's annual professional update sessions as well as through virtual classrooms. We subsequently performed root cause analyses on QPR findings per engagement to ensure we addressed likely organisational issues too.

1 2 3 4 5 6 7 CONTENTS 25



Financial statements — KPMG

Consolidated statement of financial position

As at 30 September 2018, before appropriation of results

(in thousands of euros)	Note	30 September 2018	30 September 2017*)
Assets			
Non-current assets			
Intangible assets and goodwill	12	18,185	14,427
Property, plant and equipment	13	10,598	12,366
Investments in equity accounted investees	14	4,593	3,549
Other financial assets	15	1,097	-
Deferred tax assets	10	4,105	4,735
		38,578	35,077
Current assets			
Receivables	16	127,926	117,644
Income taxes	10	1	1
Cash and cash equivalents	17	36,256	24,466
		164,183	142,111
Total assets		**202,761**	**177,188**

*) The presentation of the 2016/2017 numbers has been adjusted for comparison purposes.

The notes on pages 145 to 195 inclusive are an integral part of these consolidated financial statements.

	Note	30 September 2018	30 September 2017*)
Equity and liabilities			
Group equity	18		
Share capital		5,500	5,500
Share premium		13,500	11,020
Reserves		14,312	14,023
Profit for the year		17	289
(in thousands of euros)			
Total equity attributable to equity holders of the Company		33,329	30,832
Non-controlling interest		-7,977	-7,913
Total Group equity		**25,352**	**22,919**
Non-current liabilities			
Loans and borrowings	19	20,027	25,588
Employee benefits	20	2,675	2,657
Provisions	21	6,080	6,913
Deferred tax liabilities	10	148	30
		28,930	35,188
Current liabilities			
Loans and borrowings	19	46,022	25,322
Trade and other payables	22	73,628	63,754
Income taxes	10	-	228
Employee benefits	20	23,483	23,292
Provisions	21	5,346	6,485
		148,479	119,081
Total liabilities		**177,409**	**154,269**
Total Group equity and liabilities		**202,761**	**177,188**

1 2 3 4 5 6 7 Financial statements CONTENTS 141

The information contained herein is of a general nature and is not intended to address the specific circumstances of any particular individual or entity. The views expressed here are their personal views and do not necessarily reflect the position of their employer.

What is an audit?

"Auditing is the accumulation and evaluation of evidence about information to determine and report on the **degree of correspondence** *between* **the information** *and established* **criteria**. *Auditing should be done by a competent, independent person. - "* [4]

Stanford Plumbing & Heating
123 Madison drive, Seattle, WA, 7829Q
www.plumbingstanford.com
990-120-4560

INVOICE

BILL TO
Allen Smith
87 Private st, Seattle, WA
allen@gmail.com
990-302-1898

DESCRIPTION
Installed new kitchen sink (hours)
Toto sink
Worcester greenstar magnetic system fil
Nest smart thermostat
Worcester Greenstar 30i

SUBTOTAL	2590.00
DISCOUNT	50.00
SUBTOTAL LESS DISCOUNT	2540.00
TAX RATE	12.00%
TOTAL TAX	304.80
Balance Due	**$ 2,844.80**

Tank you for your business!

Terms & Instructions
Please pay within 20 days by PayPal (bob@stanfordplumbing.com)
Installed products have 5 year warranty.

"IFRS 15 establishes the principles that an entity applies when reporting information about the nature, amount, timing, and uncertainty of revenue and cash flows from a contract with a customer. Applying IFRS 15, an entity recognizes revenue to depict the transfer of promised goods or services to the customer in an amount that reflects the consideration to which the

…r services.

…e following five steps:

…ract. Performance obligations are …ods or services that are distinct.

ISA 520 describes the audit objective of the substantive analytical procedures as being:

1. *"To obtain relevant and reliable audit evidence when using substantive analytical procedures; and"*
2. *"To design and perform analytical procedures near the end of the audit that assist the auditor when forming an overall conclusion as to whether the financial statements are consistent with the auditor's understanding of the entity."* - ISA 520

The information contained herein is of a general nature and is not intended to address the specific circumstances of any particular individual or entity. The views expressed here are their personal views and do not necessarily reflect the position of their employer.

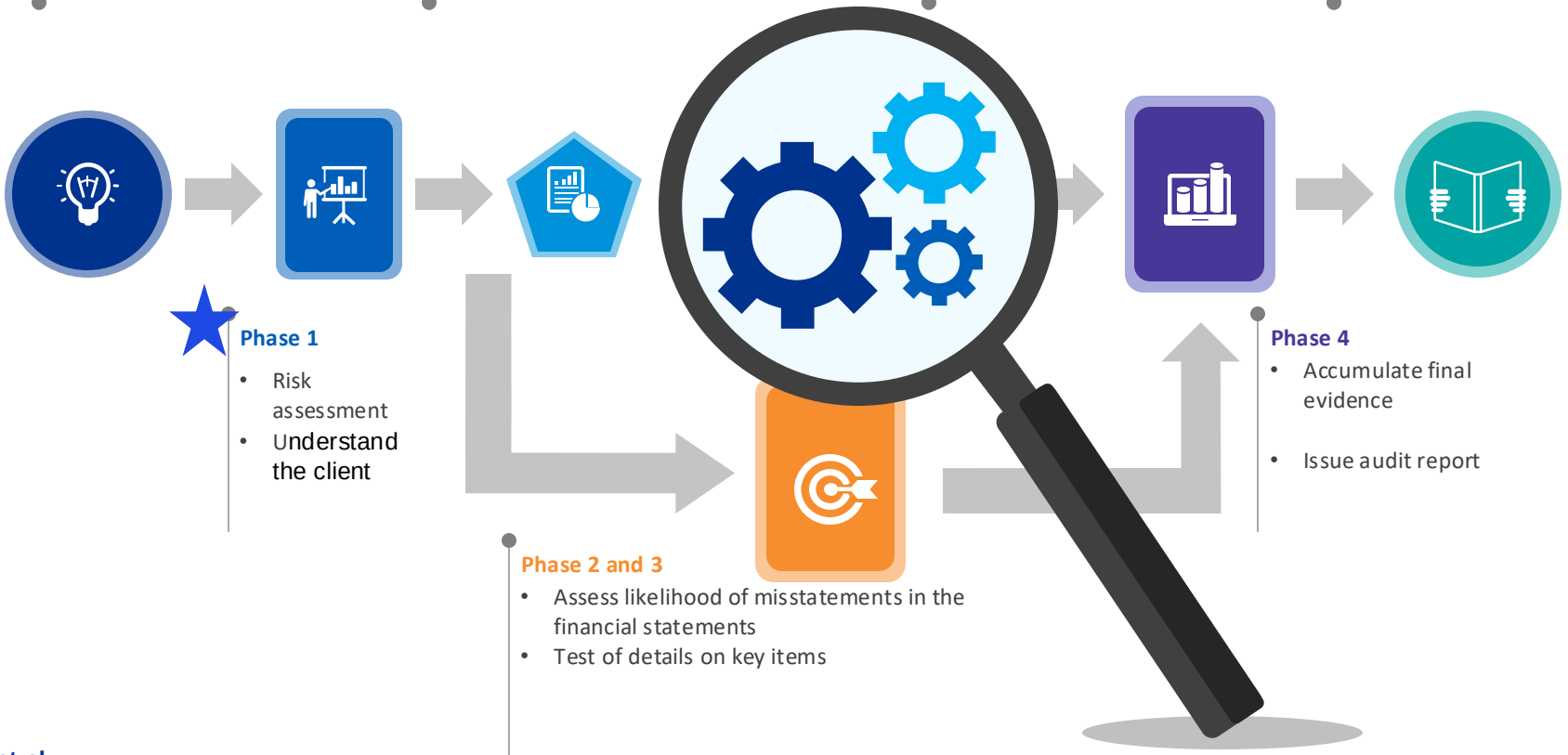
Audit phases

Phase 1
Plan and design an audit approach

Phase 2
Perform test of controls and substantive tests of transactions

Phase 3
Perform analytical procedures and test of details

Phase 4
Complete the audit and issue an audit report



Phase 1
- Risk assessment
- Understand the client

Phase 2 and 3
- Assess likelihood of misstatements in the financial statements
- Test of details on key items

Phase 4
- Accumulate final evidence
- Issue audit report

Arens et al.

The need

A recent report states, among other things, that new technology can improve audit quality. Specifically, it indicates that **data-driven methods and analysis** could make audits more effective and efficient.

Bron: https://www.accountant.nl/nieuws/2018/6/reacties-op-mca-rapport-tijd-voor-fundamentele-verandering/

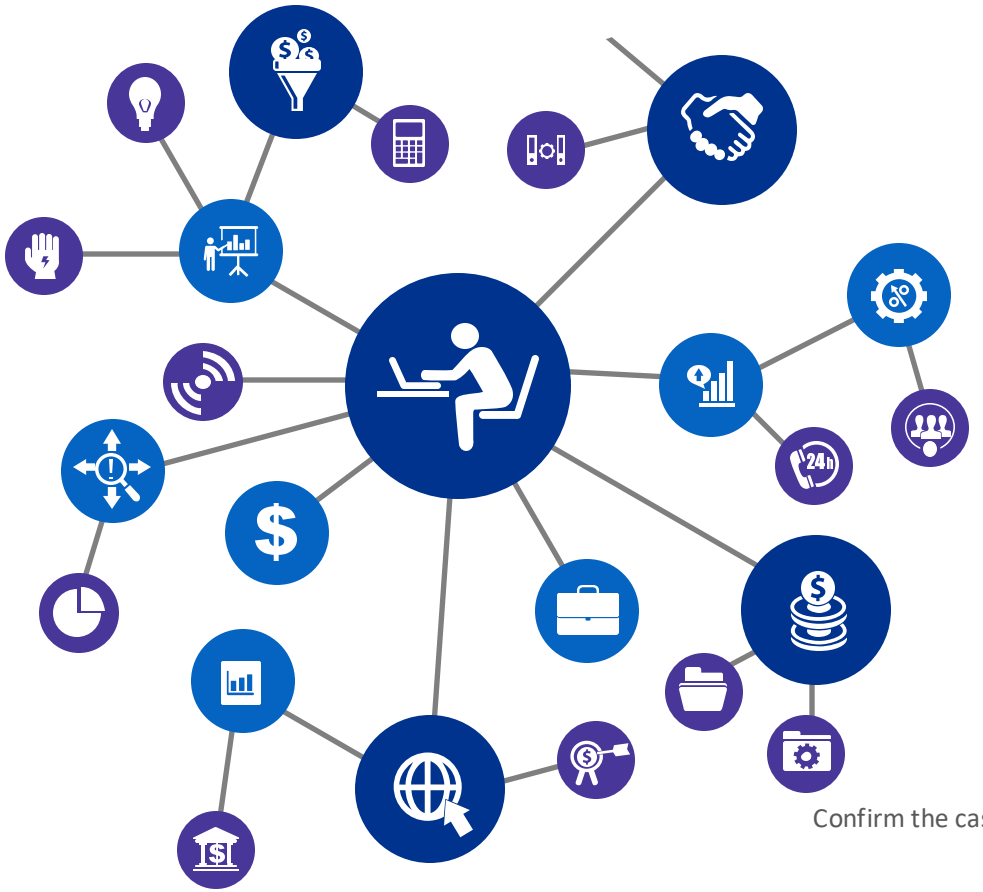
Limitations of current procedures

- **Manual in nature (sampling of invoices, counting of inventory)**
- **Cannot always be directly digitized one-on-one**
- **They study the financial system as a set of independent components**

Activities of a company

Revenue

Audit revenue by sampling the invoices



Structural knowledge

Increased efficiency

Audit Cash

Confirm the cash position of a client

A network model

Data sources of an audit

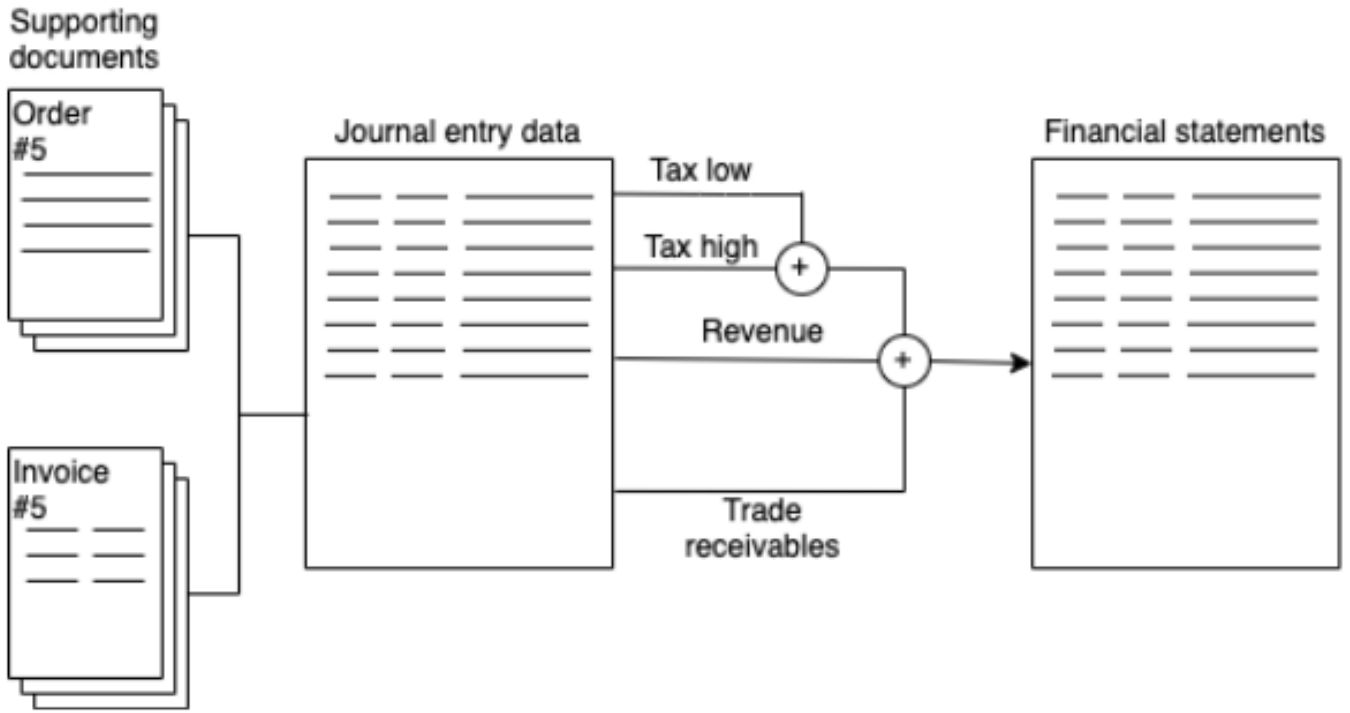
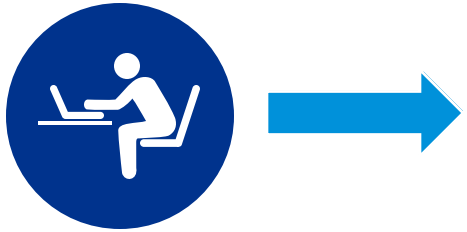


Figure 1.2: This high-level data overview shows how the aggregated information is connected to the documents recorded in the company's systems. The financial statements (right) are an aggregate representation of the journal entry data (middle), which is connected to supporting documents such as invoices, work orders, and more (left).

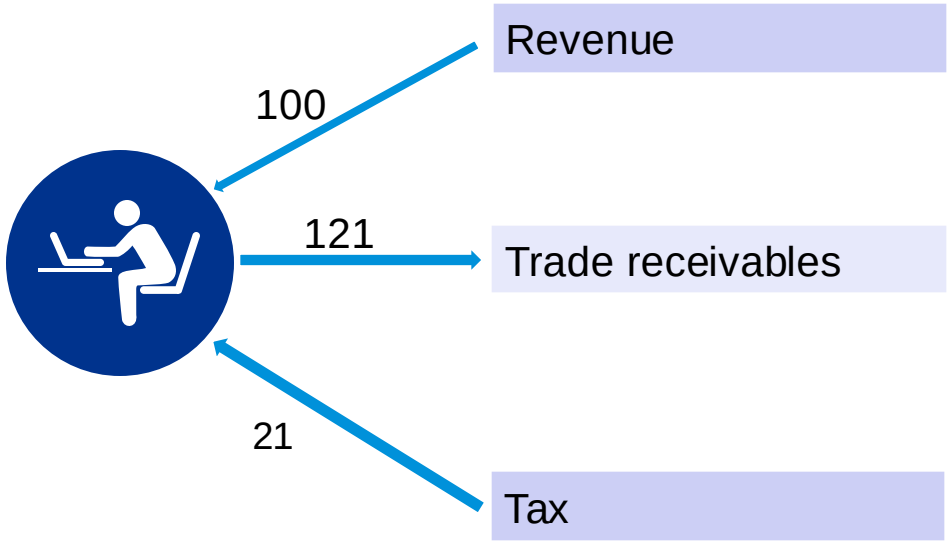
The data: Journal entries



Financial Account	Journal	Date	Debit	Credit
Revenue	Sales ledger	02-11-2019	-	100
Trade receivables	Sales ledger	02-11-2019	121	-
Tax	Sales ledger	02-11-2019	-	21

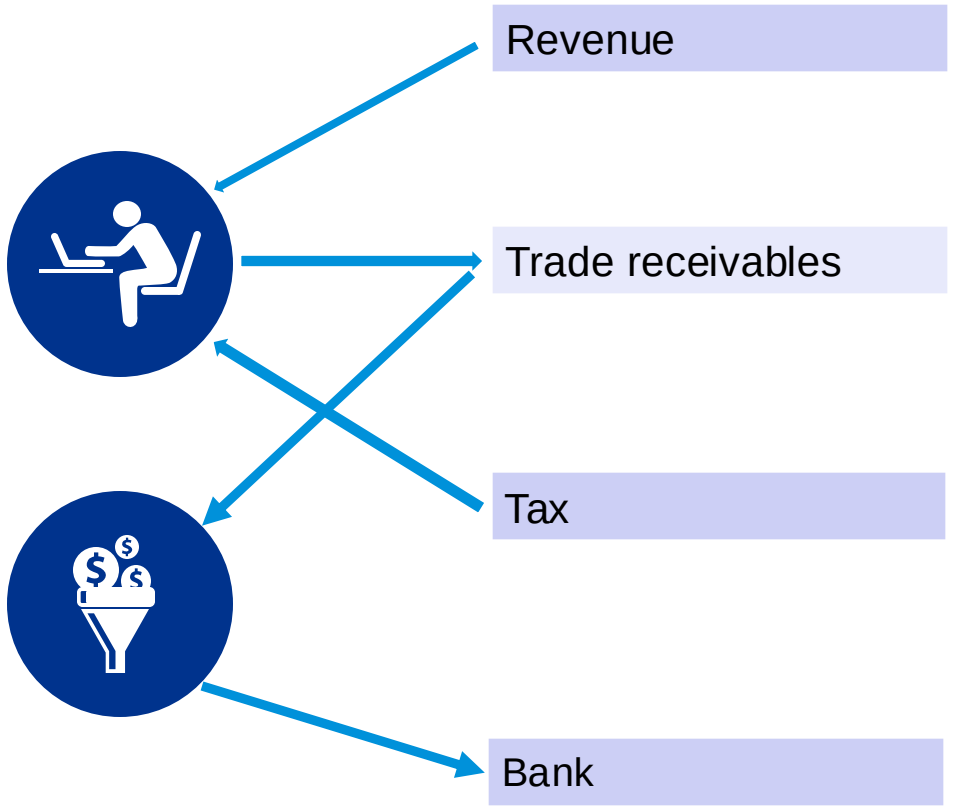
Boersma, Marcel, et al. "Financial statement networks: an application of network theory in audit." *The Journal of Network Theory in Finance* 4 (2018).

The data structure: a bipartite network



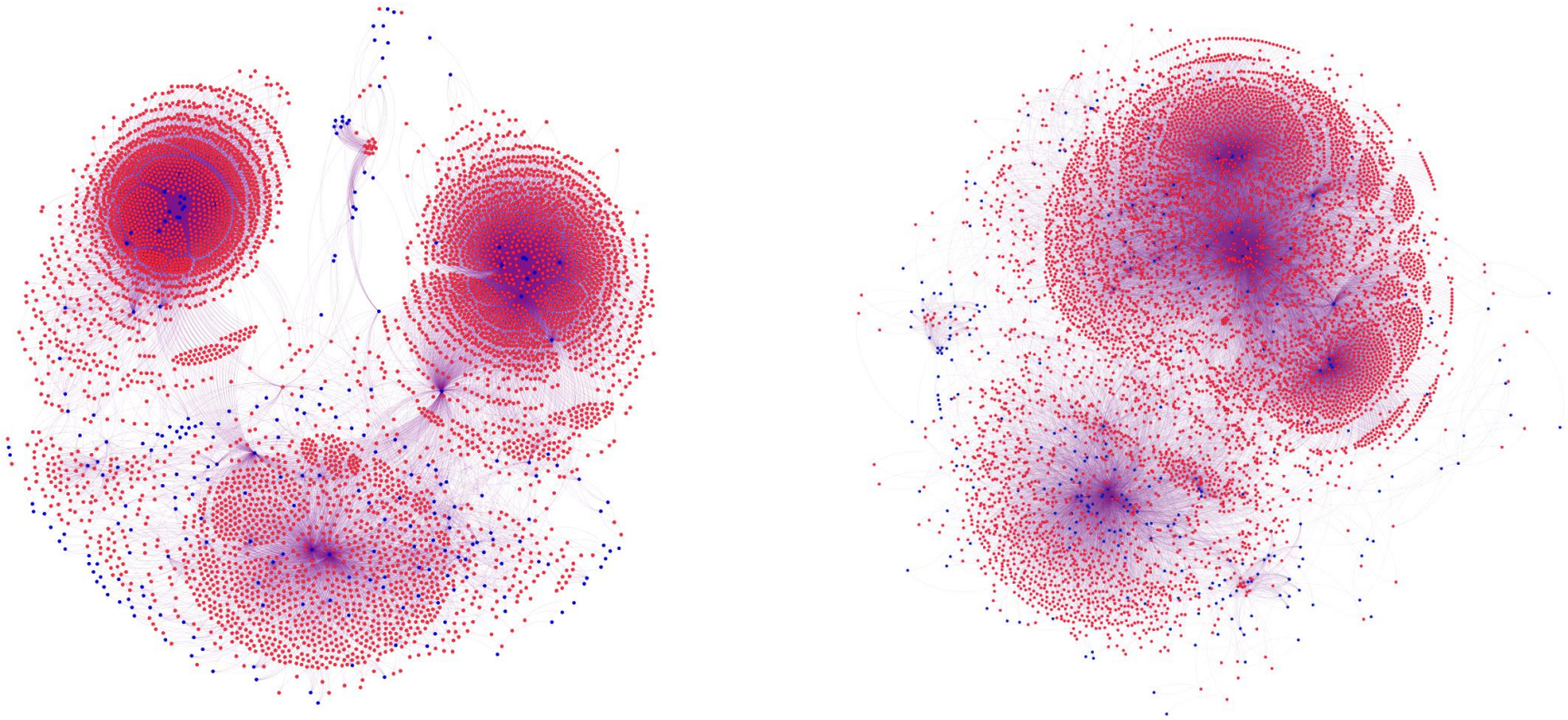
Boersma, Marcel, et al. "Financial statement networks: an application of network theory in audit." *The Journal of Network Theory in Finance* 4 (2018).

The data structure: a bipartite network



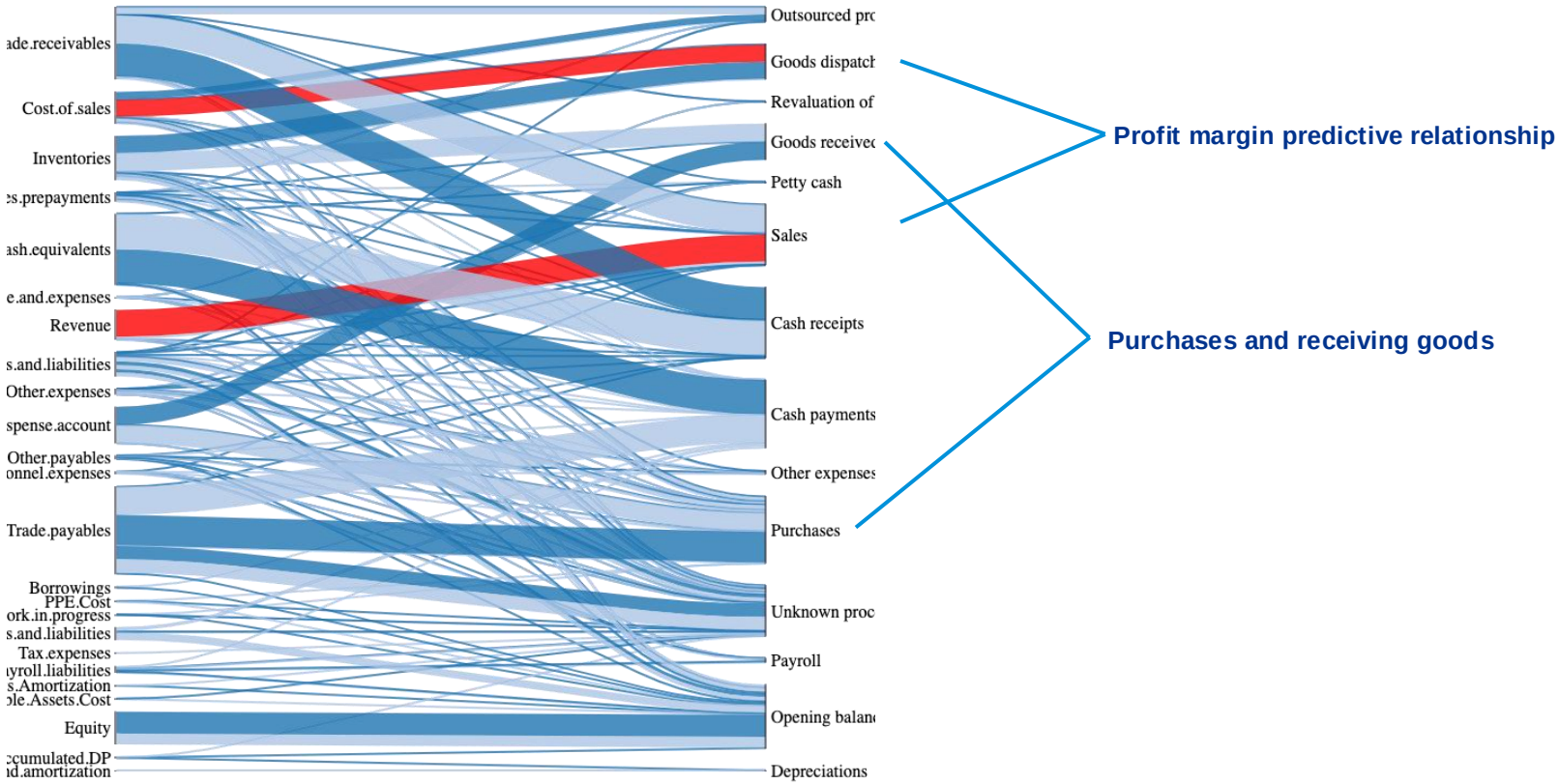
Boersma, Marcel, et al. "Financial statement networks: an application of network theory in audit." *The Journal of Network Theory in Finance* 4 (2018).

Real networks



Boersma, Marcel, et al. "Financial statement networks: an application of network theory in audit." *The Journal of Network Theory in Finance* 4 (2018).

Simplified network



Boersma, Marcel, et al. "Financial statement networks: an application of network theory in audit." *The Journal of Network Theory in Finance* 4 (2018).

Audit insights

Auditors can use the network for risk assessment by:

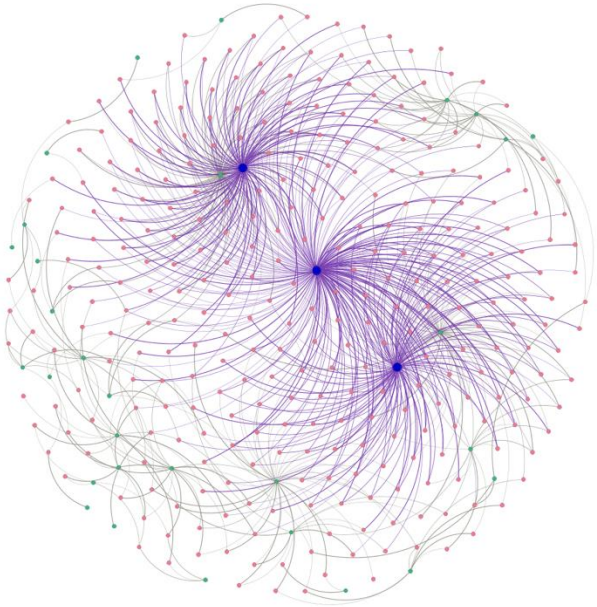
- Comparing their understanding of a client's financial structure with the network structure

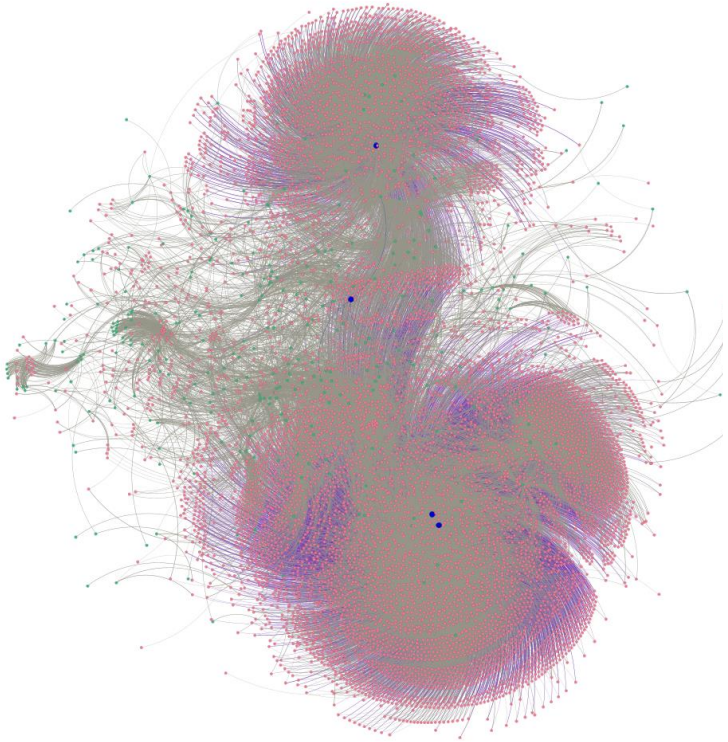
Auditors can use the network to obtain substantive evidence by:

- A way to assess the concistency between financial flows for audit evidence

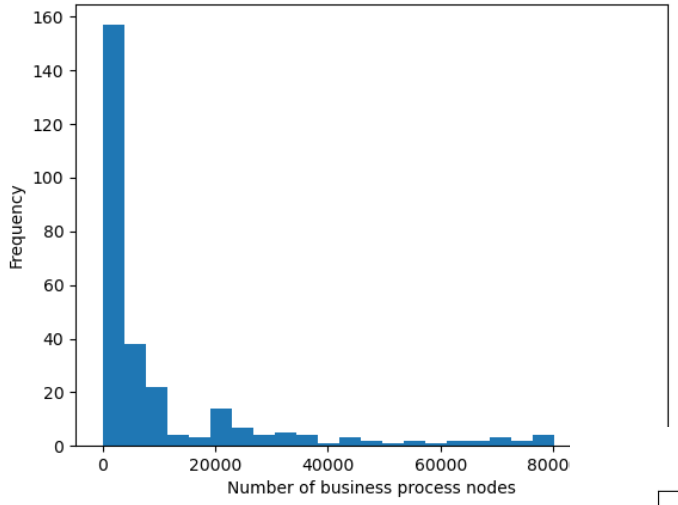
Network statistics

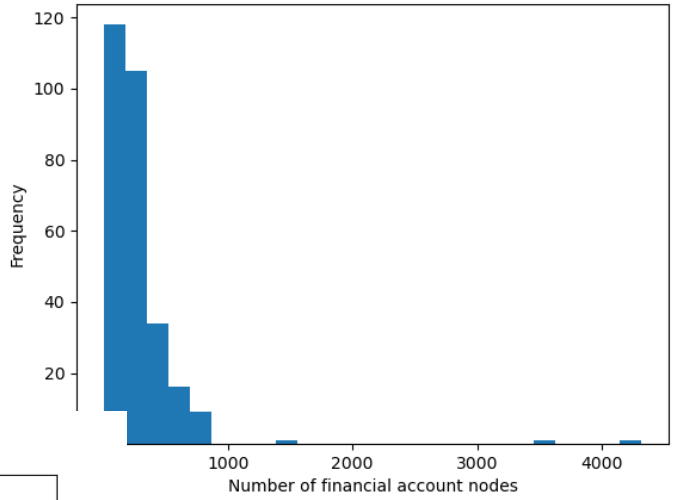
Understanding the networks

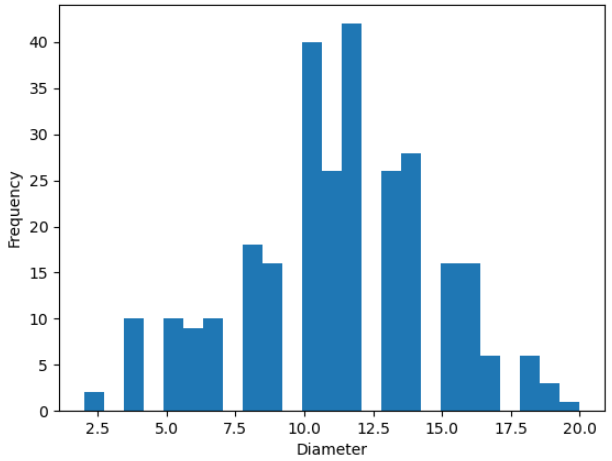




Baseline statistics







The information contained herein is of a general nature and is not intended to address the specific circumstances of any particular individual or entity. The views expressed here are their personal views and do not necessarily reflect the position of their employer.

Baseline statistics: **degree distribution**

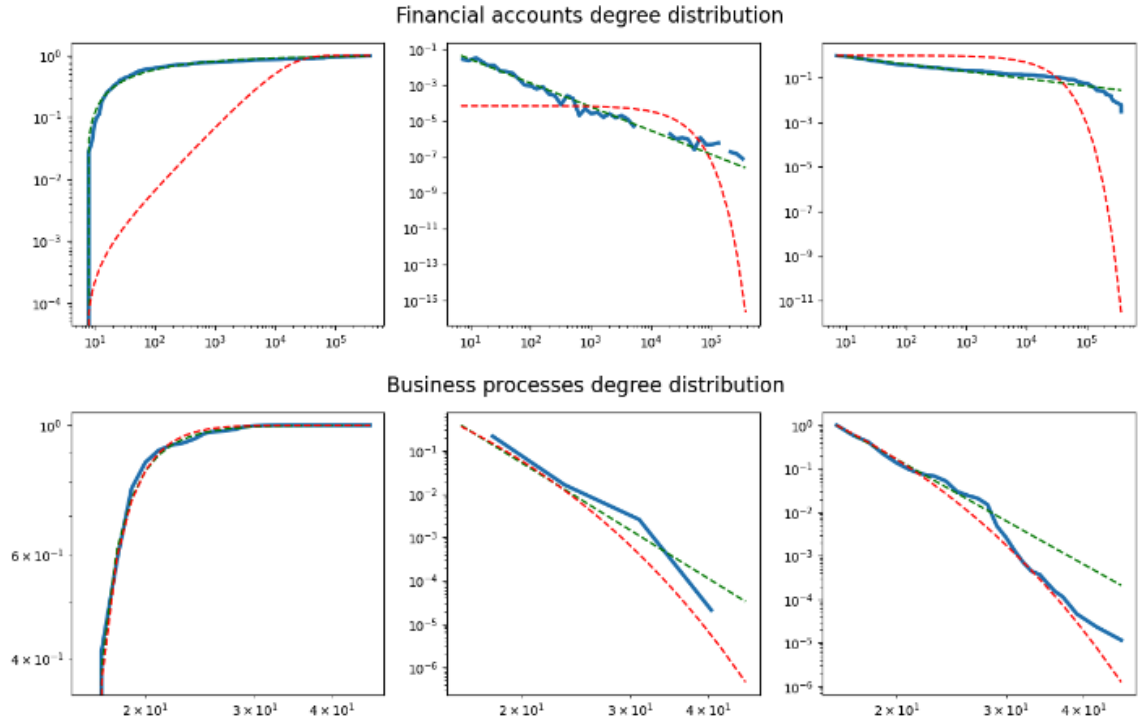
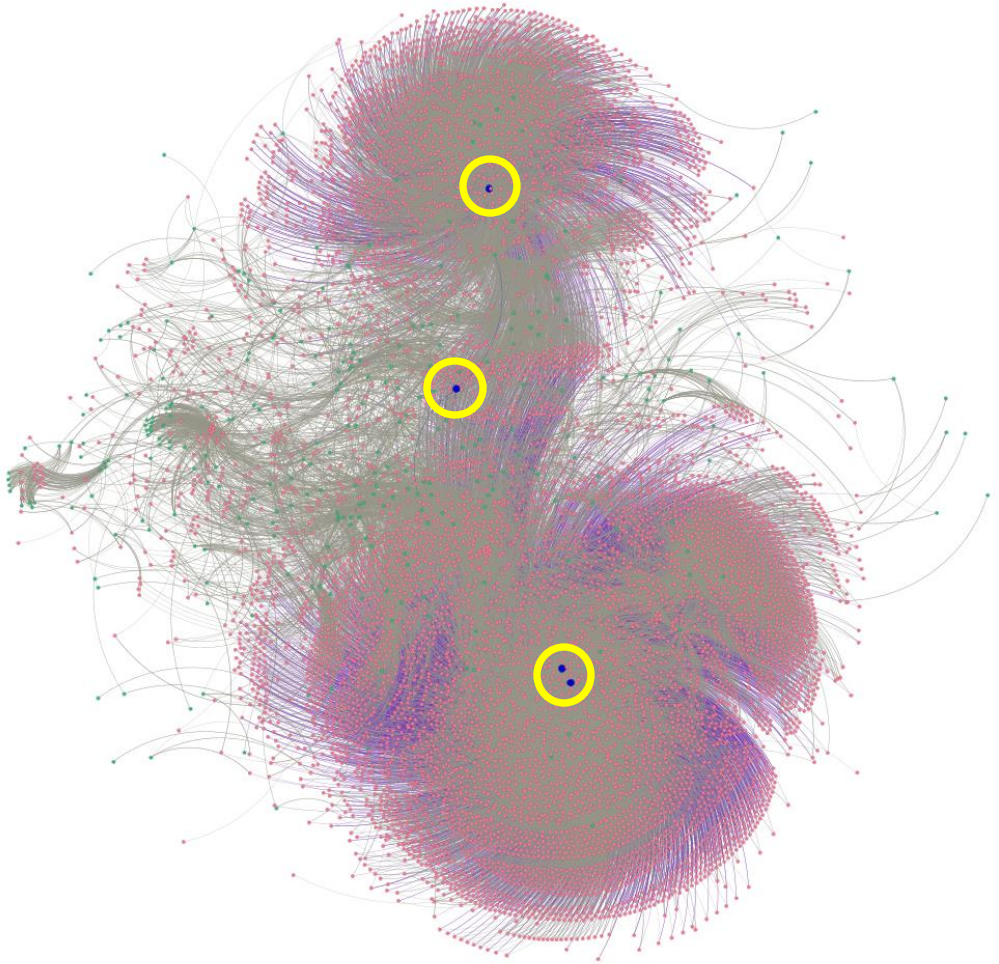


Figure 8. On the left is the cumulative density function, in the middle is the probability density function, and on the right is the complementary cumulative density function for financial statements network 62 (large) with 391.688 nodes in total. The top row is the financial account nodes distributions, and the bottom row is the business process nodes distributions. The green dashed line is a power-law distribution, the red dashed line is an exponential distribution, and the solid blue line is the empirical distribution. Note that the axes are on a log scale.

Analysis: what are important parts of the financial s



Financial

- **hubs**
- **gatekeepers**
- **core-activities**

Results and conclusion

- Number of business process nodes determines the size
- An increase in the number of nodes does not result in a corresponding proportional increase in the network's diameter
- we found evidence of a heavy-tailed degree distribution in financial account nodes, leading to hubs of interest to auditors
- Results confirm, for a small sample, that the centrality measures highlight important hubs in the financial structure, increasing the auditor's understanding of the company.

Audit insights

Baseline statistics:

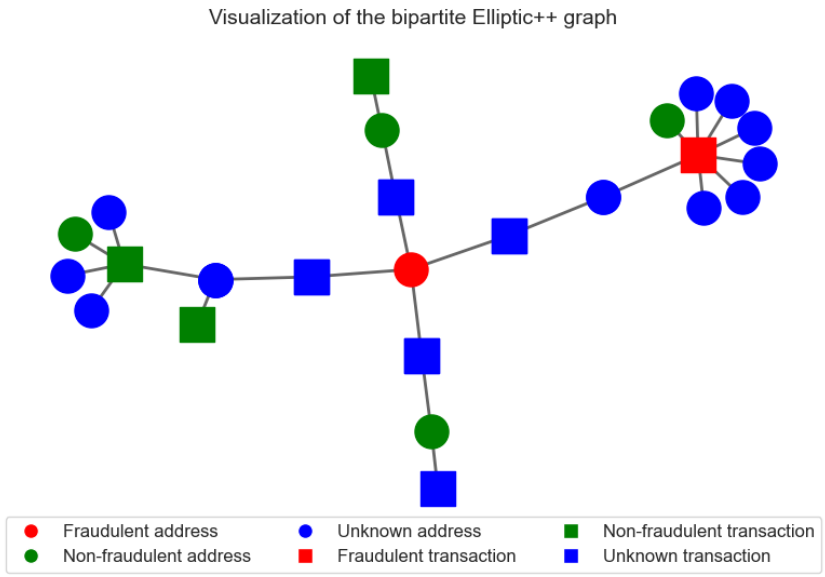
- used to assess whether a new client's financial structure is in line with expected statistics (power-law distribution of financial account nodes, diameter expectations, etc).

Centrality measures

- Financial Gatekeepers (betweenness centrality)
- Financial Hubs (closeness centrality)
- Financial Core-activities (degree centrality)

Semi-supervised Anomaly Detection with Granger Causal Explanations for Financial Networks

We propose a semi-supervised graph neural network (GNN) that learns to flag fraudulent items based on limited labeled and unlabelled data points. The flagged items are explained by highlighting related items in the network using Granger causality. We use a real-world dataset, Elliptic++, based on Bitcoin transactions, to demonstrate the algorithm. We show that we obtain high-performance scores, but more importantly, we provide causal explanations for identified fraud based on graph structure. This capability can help auditors thoroughly investigate the implicated group and its interactions, offering a comprehensive understanding of the anomalies.



Nguyen et al. 2024 (work in progress)

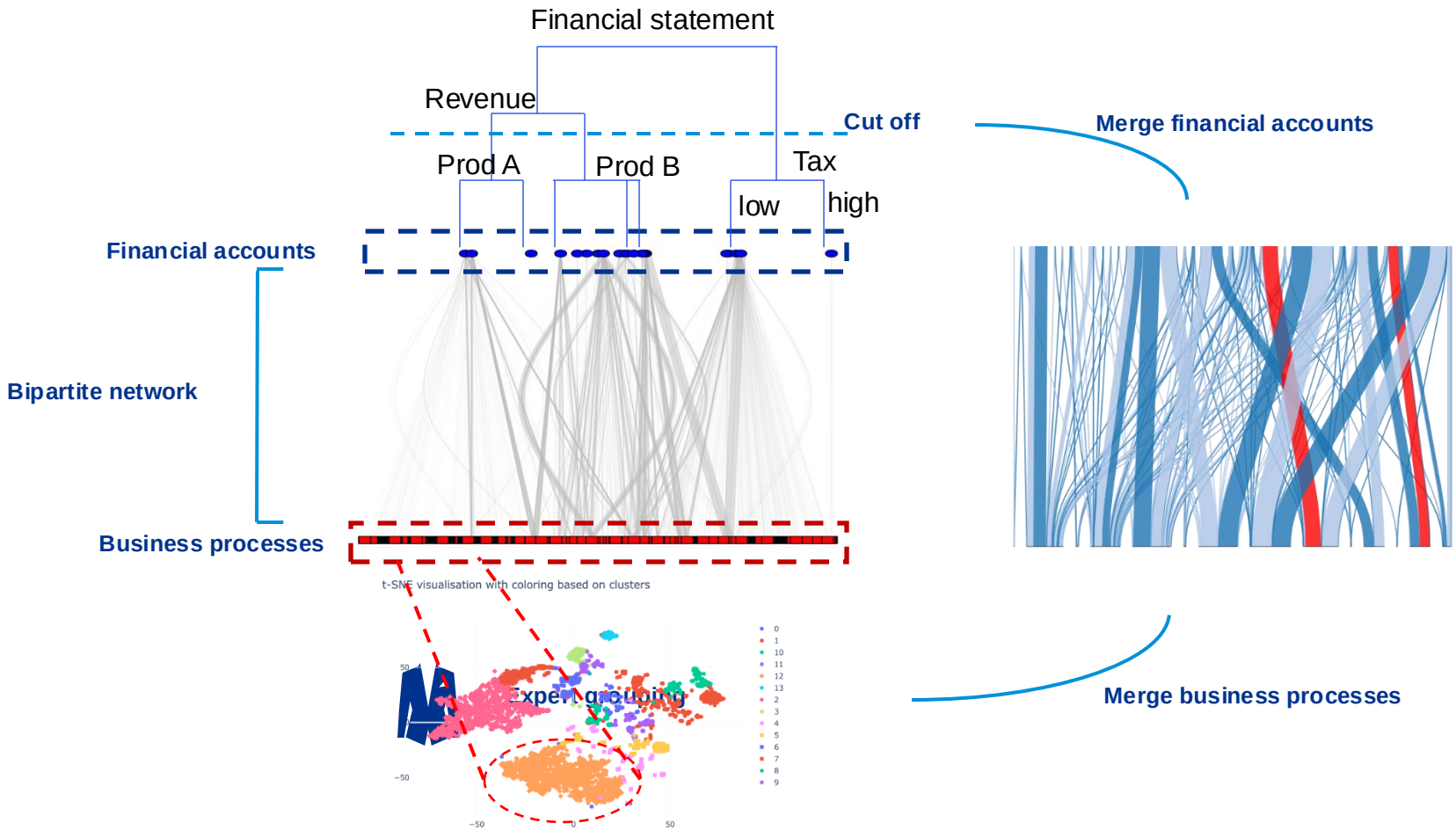
Network coarse-graining

Network coarse graining

Motivation: Simplify the detailed networks to provide a high-level overview of the financial structure

Results: We found an effective way to coarse-grain the network of detailed financial statements. The method we proposed groups the nodes in the network in an automated way; the resulting groups show a high resemblance with the groups annotated by an auditor. We resolved the detailed financial statements network limitation, a manual coarse-graining procedure. In addition, the derived node embeddings can be hierarchically ordered, a valuable property in case the auditor wants to adjust the granularity of the high-level representation. The auditor can use this property to dynamically explore a client's financial structure.

Simplifying the network



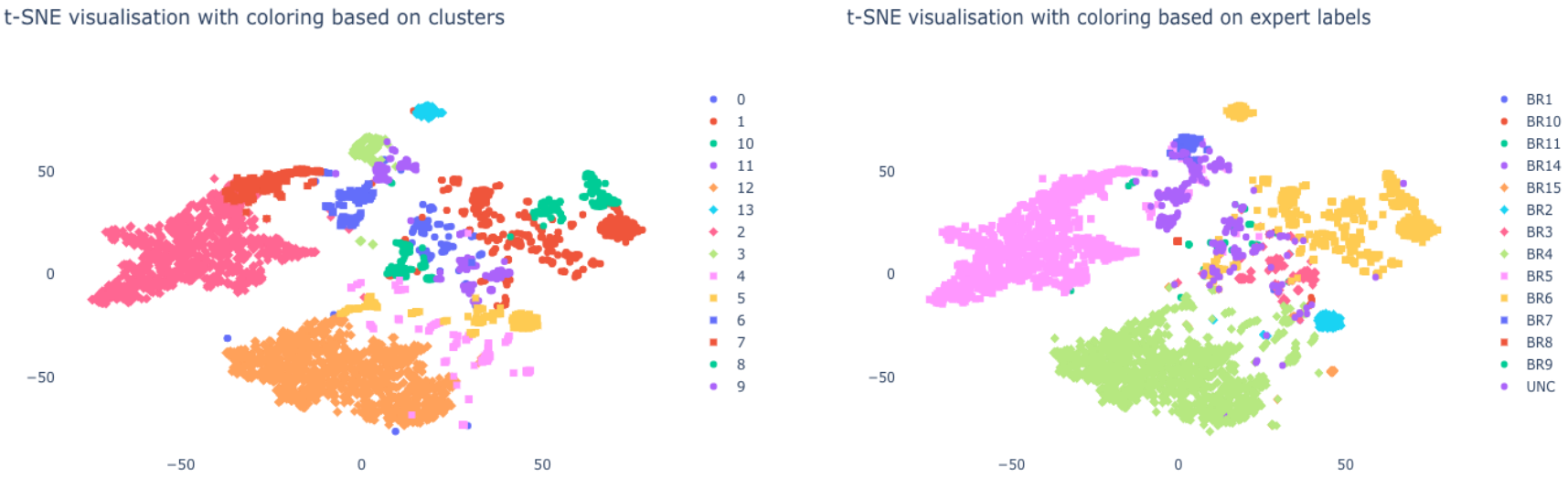
Boersma et al. 2020 Scientific Reports

Expert vs clusters: company A

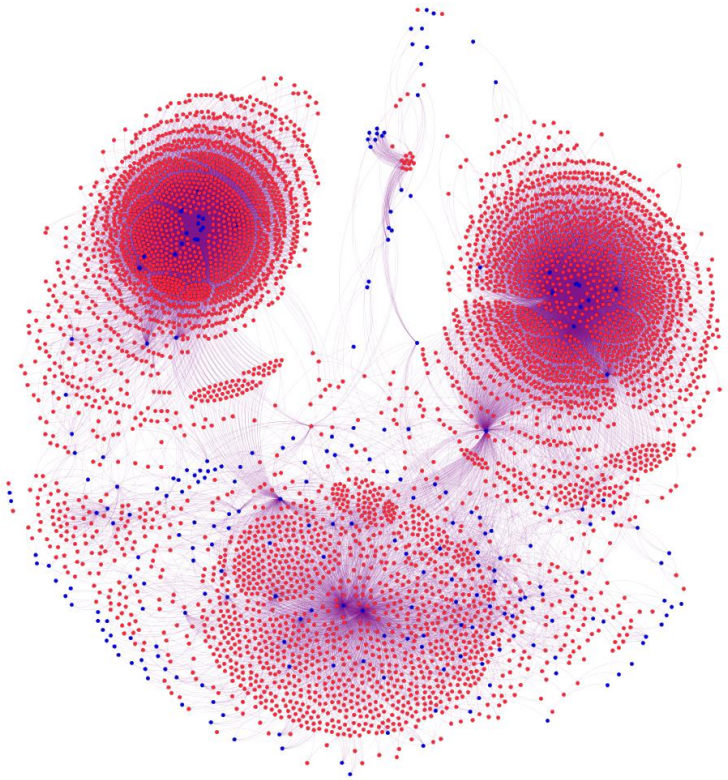
Clusters

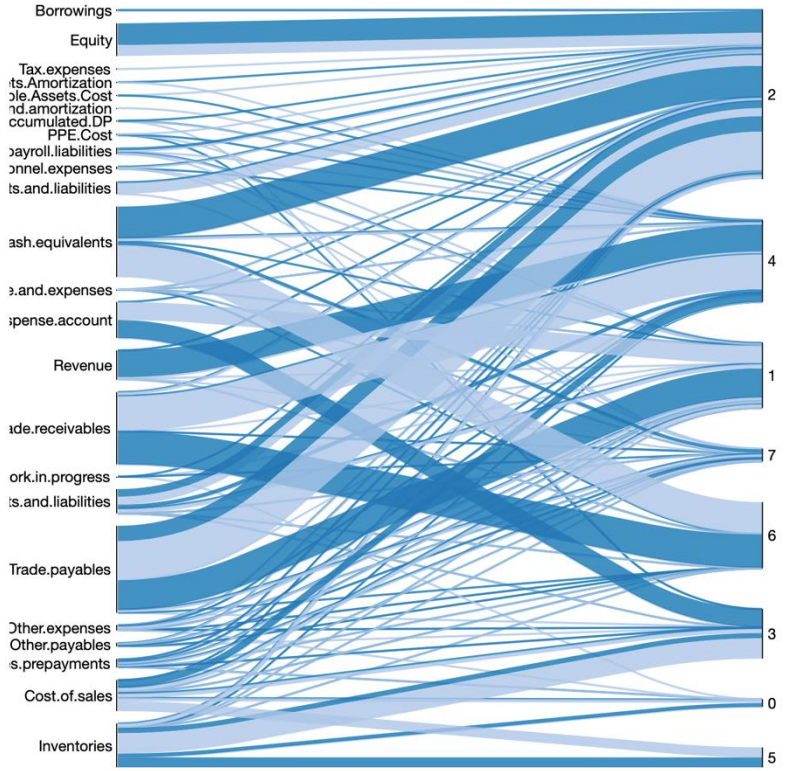
Expert

V-score: 0.71



Results





The information contained herein is of a general nature and is not intended to address the specific circumstances of any particular individual or entity. The views expressed here are their personal views and do not necessarily reflect the position of their employer.

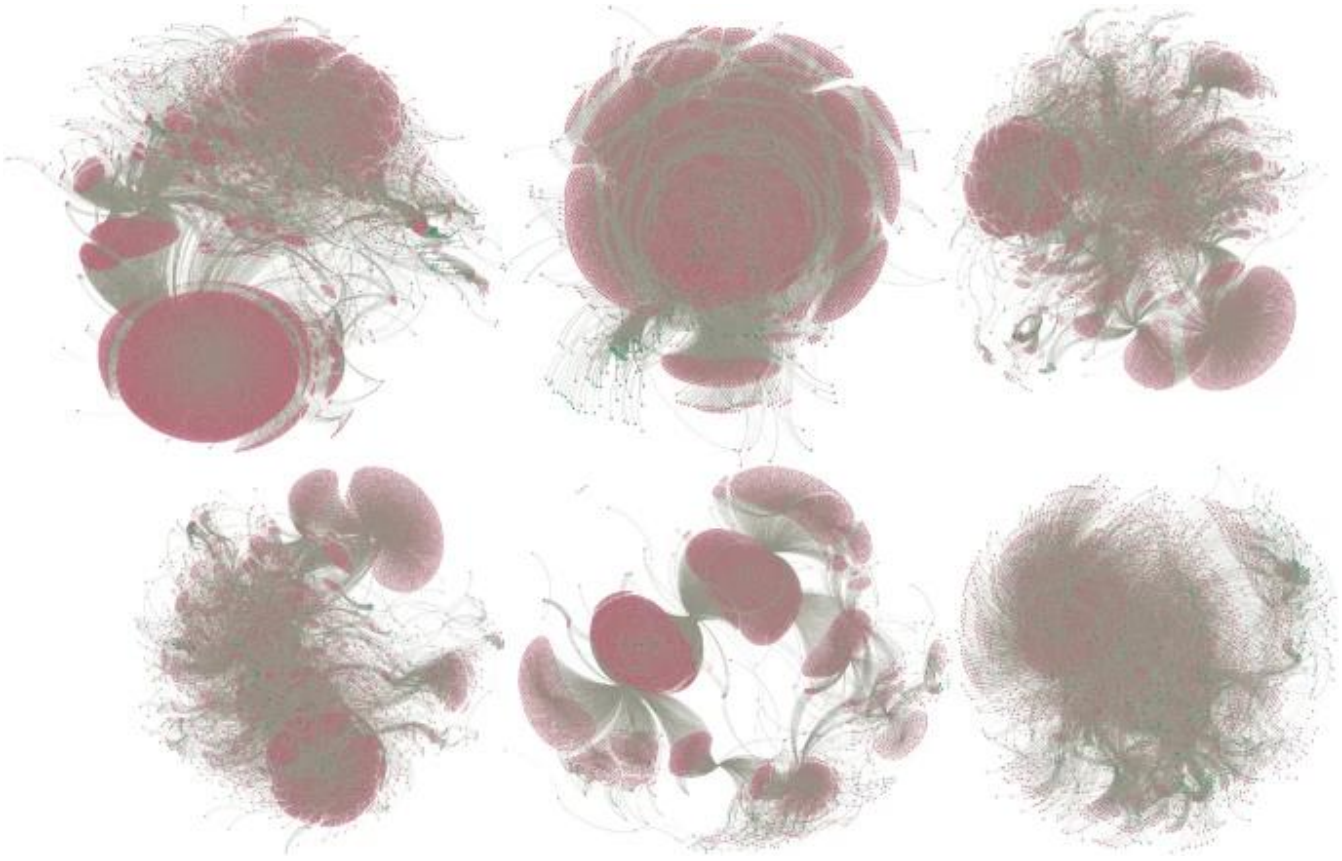
Network similarity

Network similarity

Motivation: Measure cross-sectoral structural similarities from financial networks

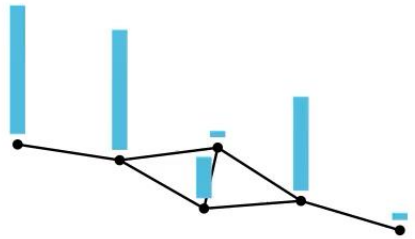
Results: Our approach is based on the analysis of 300+ real transaction datasets that provide auditors with relevant insights. We detect significant changes in bookkeeping structure and the similarity between clients. For various tasks, we obtain good classification accuracy. Moreover, closely related companies are near in the embedding space while different industries are further apart suggesting that the measure captures relevant aspects.

Are these networks similar?



From network to distribution

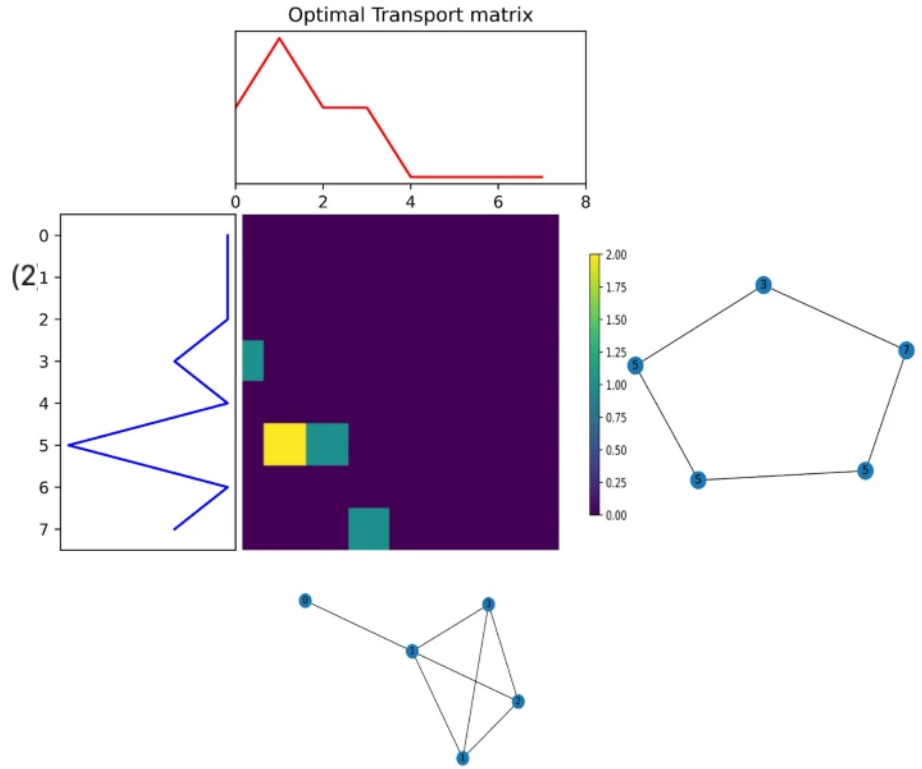
$$a^{h+1}(v) = \frac{1}{2}\left(a^{h}(v) + \frac{1}{deg(v)} \sum_{u \in N(v)} w((v,u))a^{h}(u)\right)$$



How do we measure similarity?

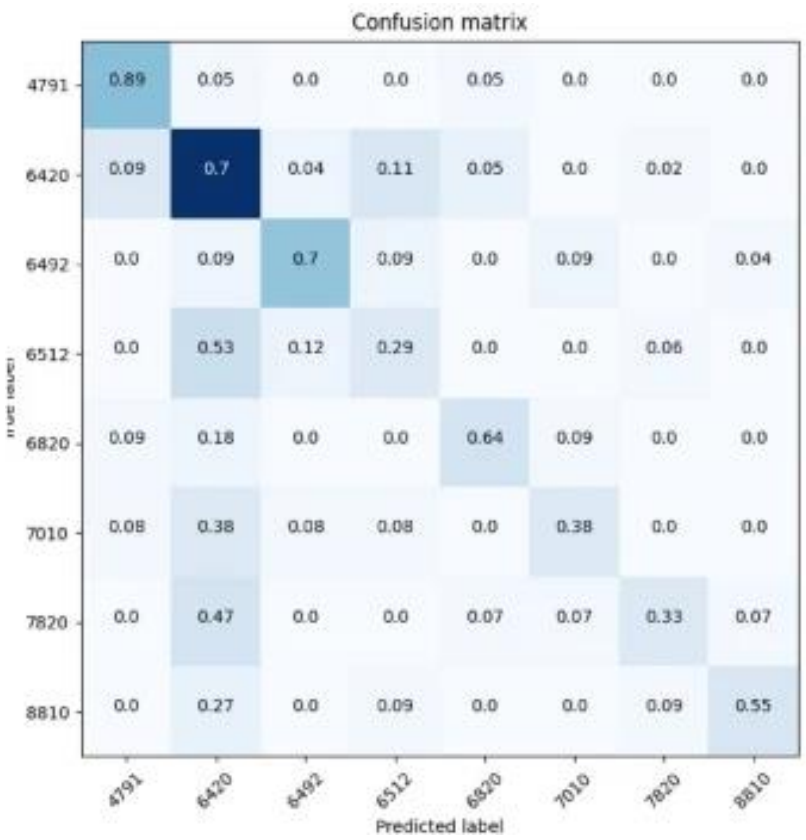
We measure the earth-movers distance.

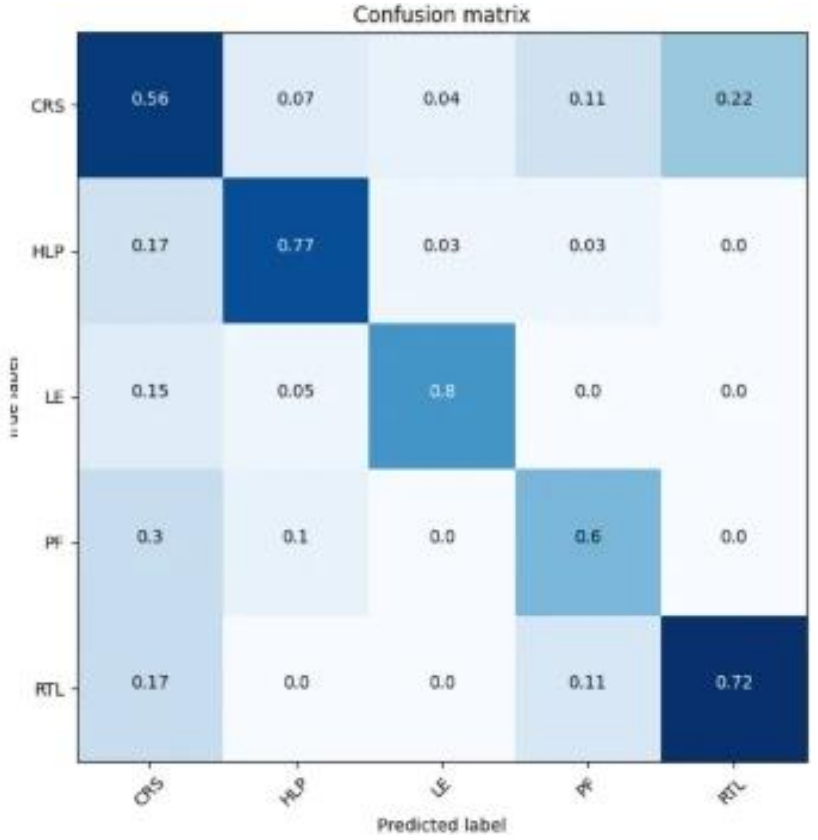
$$W_p(\sigma, \mu) = \left(\inf_{\gamma \in \Gamma(\sigma,\mu)} \int d(x,y)^p d\gamma(x,y) \right)^{\frac{1}{p}}$$



The similarity measure results

Classification results:





Audit insights

Auditor can use this for assessing the audit risk by:

- Comparison with industry peers
- Comparison with prior year network structures

Financial statement networks

Outlook and discussion

Contributions

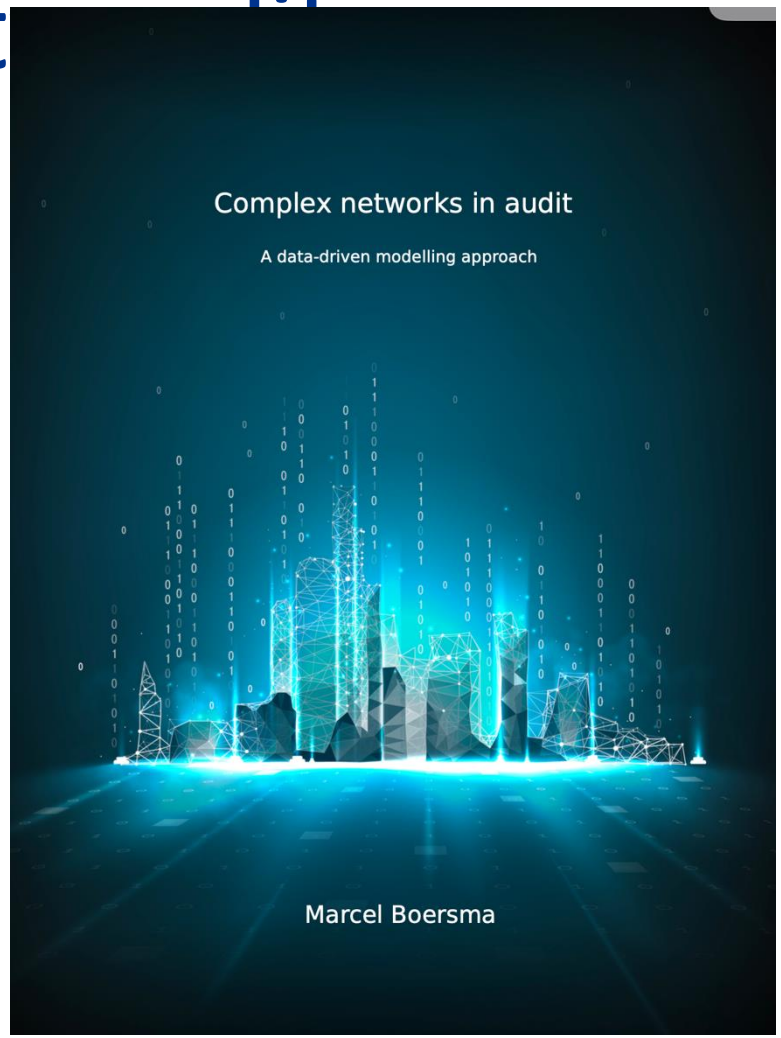
- A generic network representation of transaction data
- Base line statistics of Financial statements network
- A way to coarse-grain the network to provide a high-level understanding of the financial flows
- Similarities across companies

Conclusion: Our research focuses on developing data-driven audit methods to enhance the overall quality of audits. We achieved this by revealing the financial structure as a bipartite network. We answered multiple relevant audit questions by analyzing the network structure, demonstrating the chosen representation's usefulness. We showed that the financial statements network could be applied to risk assessment procedures.

Outlook:

- Financial statements network for fraud analysis in audit
- Assurance from models

Data driven audits – paving the way for higher qualit



The information contained herein is of a general nature and is not intended to address the specific circumstances of any particular individual or entity. The views expressed here are their personal views and do not necessarily reflect the position of their employer.

Some or all of the services described herein may not be permissible for KPMG audit clients and their affiliates or related entities.

kpmg.com/socialmedia

Marcel Boersma

boersma.marcel@kpmg.nl

mboersma@uva.nl

Document Classification: KPMG Public