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Making News Media Ownership Chains Transparent by Relational Databases

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Abstract

The multi-tiered shareholder identification and registration systems are dominant within the European Union member States, but in the Nordic countries, the holding structure is based on a direct holding model. Share registers of all listed companies are public, so basically, anyone may have a full outlook on the corporate ownership structure whenever they want.

However, even the Nordic corporate governance model allows you to hide your ownership from public scrutiny by using other companies, most preferably unlisted ones, as intermediaries. The more complicated the chain of intermediaries, the more difficult it is to understand the ownership pattern and level of ownership concentration, which is especially important when evaluating the diversity and functioning of the news media markets.

This is why maximum transparency requires not only public share registers but also a structural database, which has also been designed to show the full chain of direct and indirect ownership of each legal owner. This article analyses the relational database model developed for studying and presenting multilevel direct and indirect ownership structures of European news media in the first phase of the *Euromedia Ownership Monitor* project funded by the European Union.

Keywords

shareholders, transparency, indirect ownership, relational database, news media

Tornar as Cadeias de Propriedade dos Média Noticiosos Transparentes Através de Bases de Dados Relacionais

Resumo

Os sistemas de identificação e registo de acionistas multinível predominam nos Estados-membros da União Europeia. No entanto, nos países nórdicos a estrutura de participação é baseada num modelo de participação direta. Os registos de ações de todas as empresas cotadas em bolsa são públicos, permitindo a qualquer pessoa aceder a uma visão completa da estrutura de propriedade das empresas a qualquer momento.

Contudo, mesmo o modelo nórdico de governança empresarial permite ocultar a sua propriedade do escrutínio público, através do recurso a outras empresas, preferencialmente não cotadas em bolsa, como intermediárias. Quanto mais complexa for a cadeia de intermediários, mais difícil se torna compreender o padrão de propriedade e o nível de concentração da propriedade, o que é especialmente relevante para a avaliação da diversidade e do funcionamento dos mercados dos média noticiosos.

Por essa razão, a máxima transparência exige não só acesso aos registos públicos de ações, mas também a uma base de dados estrutural, concebida para apresentar toda a cadeia de propriedade direta e indireta de cada proprietário coletivo. Este artigo analisa o modelo de base de dados relacional desenvolvido para estudar e apresentar as estruturas multinível de propriedade direta e indireta dos média noticiosos europeus, na primeira fase do projeto *Euromedia Ownership Monitor*, financiado pela União Europeia.

Palavras-chave

acionistas, transparência, propriedade indireta, base de dados relacional, média noticiosos

1. Introduction

There are several different shareholder identification and registration systems in the world, both direct and indirect, but multi-tiered systems are dominant worldwide as well within the European Union (EU) member States (Connan et al., 2015; European Post Trade Landscape, 2017). However, the Nordic countries (Denmark, Finland, Norway and Sweden) are exceptions in this context, as their holding structures are based on a direct holding model. Share registers of all listed companies are public, so basically, anyone may have a full outlook on the corporate ownership structure whenever they want (Lekvall, 2014; Marjosola, 2018). This is also the main reason why there is no special legislation concerning ownership transparency of media companies in Nordic countries, as all the companies are expected to be transparent (Craufurd Smith et al., 2021; Grönlund et al., 2023).

However, the Nordic corporate governance model based on the publicity principle is far from perfect, and it does not guarantee full transparency of company ownership. For example, in Finland, the list of shareholders should be at the company's headquarters so that anybody can see it without a separate request. You should also be able to get a copy of the shareholder register just by reimbursing the cost of copying. While the system works rather well with public companies, sometimes it is difficult to get the information directly from limited companies. In addition, although all the up-to-date company ownership information would be available in a public trade register database, there can be a relatively high administrative fee, which creates a significant limitation to public access to this information (Craufurd Smith et al., 2021; Grönlund et al., 2023).

For example, in the United Kingdom, share and shareholder information is publicly available through the Companies House (n.d.) register. This allows anyone interested to easily access and search for a company on the Companies House platform. One can find details such as the number and type of shares in the company, as well as ownership information. However, it is worth noting that while this information is accessible, Companies House might not always have the most up-to-date share data for a company. Initially, share and shareholder details are included in a company's incorporation documents. Any changes to shares post-incorporation do not require immediate reporting and are typically updated when the company submits its annual confirmation statement.

This also makes it possible for the domestic owners of listed companies to effectively hide their ownership from public scrutiny even though they would not be allowed to have indirect holdings through nominee accounts. It would be completely legal to use other companies and, most preferably, also unlisted companies as intermediaries. The more complicated is the chain of intermediaries, the more difficult it is to understand the ownership pattern. This is why maximum transparency requires not only public share registers but also a structural database, which has also been designed to show the full chain of direct and indirect ownership of each legal owner.

This article analyses the relational database model developed for studying and presenting multilevel direct and indirect ownership structures of European news media in the first phase of the *Euromedia Ownership Monitor* (*EurOMo*) — a project funded by the EU. The European Democracy Action Plan, introduced by the European Commission in December 2020, aims to strengthen citizen empowerment and enhance the resilience of EU democracies. In line with this, *EurOMo* seeks to improve transparency in news media ownership and control across EU nations (see Tomaz, 2024). It provides searchable databases on (a) ownership and control of major news outlets, (b) relevant legislation, and (c) digital platforms. Following the EU Commission's mandate, *EurOMo* is dedicated to its mission by offering data on media ownership structures, identifying gaps, and assessing transparency risks. This includes maintaining a comprehensive database on news media ownership across EU countries and producing country-specific reports on transparency levels.

We focus on structural aspects of ownership structures in relational databases. Indirect ownership relationships weaken the transparency of media ownership structures because they are not explicitly represented in the ownership structure that consists of direct owner-owned fact pairs. An owner is a legal or natural person. An owned entity is, in turn, a legal owner or an outlet. The outlet does not own any legal owner or another outlet. To manipulate ownership relationships systematically, they must be modelled and stored in a database. The database is based on a data model. According to Ullman (1988): "the data model is a mathematical formalism with two parts: 1. A notion for describing data, and 2. A set of operations used to manipulate that data" (p. 32). For example, relational databases follow the relational data model. In practice, structured query language (SQL) involves the operations of the relational data model for manipulating data.

In literature, databases are usually understood in a more non-specific way. Any collection of documents may be called a database, although there are no structures or operations for manipulating data. Further, a web service for searching data may be called a "database". However, the web service is not a database; it is built on top of a database. The user can make predefined queries where different parameters can be stated. Based on these parameters, actual database queries are formed invisibly to the end user.

In this paper, we demonstrate how databases can be utilised for both storing and analysing the structure of media ownership. We use relational databases that are the most familiar nowadays. We demonstrate how different aspects of the ownership structure can be queried. Recursive queries are the most advanced, and they are needed to analyse and aggregate indirect relationships. In practice, this means that a natural person owns a company, which owns another company that has its own ownership, and so forth. These kinds of ownership chains may have different lengths. Further, a person can own an outlet via several ownership chains, which creates more challenges in query formulation.

Although there are open databases of media ownership, to the best of our knowledge, no database solution with manipulation rules has been published so far. In short, we aim to make the manipulation of media ownership structures transparent.

The remainder of the paper is organised as follows: Section 2 introduces the existing databases and services of media ownership. Section 3 addresses the ownership structure and outlines the sample structure used throughout the paper. Then, the database structure is defined, and the sample data are placed in the database structure. In Section 5, SQL-based analysis is demonstrated with examples. Section 6 explores possible extensions. Finally, the conclusions are presented.

2. Related Works

The most important and complete publicly available and functional database of news media companies in Europe so far is the MAVISE online database, which is managed and maintained by the European Audiovisual Observatory in Strasbourg and financed by the EU. However, while MAVISE covers audiovisual services in 42 European countries and Morocco, it provides no information on other sectors of media industries (Antoniou et al., 2021). For the audiovisual sector, MAVISE has advanced query options based on the property values or their parts. The service provider and the final owner are represented as properties of the services. The final owner represents the highest ownership level controlling the service. However, only one natural or legal person is shown as the final owner. Thus, we conceptualise that MAVISE is not focused on analysing actual ownership chains or structures.

There have also been some academic and civil society-based initiatives to map news media ownership in Europe. Since 2014, the *Media Pluralism Monitor* project by the

Centre for Media Pluralism and Media Freedom at the European University Institute has evaluated annually the transparency of media ownership, the plurality of media providers and the plurality of digital markets in all EU member States and candidate countries. These indicators are based on several variables also concerning national media ownership transparency legislation and its implementation (e.g., Ylikoski & Ala-Fossi, 2024). In addition, Reporters Without Borders has published Media Ownership Monitor reports on both European and so-called "developing countries". However, the focus of these initiatives has been on producing reports rather than creating any functional relational ownership databases (Antoniou et al., 2021; Craufurd Smith et al., 2021). The Media Ownership Ireland (MOI; n.d.) database is an exception to that rule. It was originally initiated by the Broadcasting Authority of Ireland but designed, implemented, and maintained by Dublin City University. The database covers all sectors of media, but only in Ireland. MOI supports the search for different types of outlets and their shareholders. It enables step-by-step navigation in an ownership structure. However, MOI does not support recursive queries that are needed to formulate aggregated views of indirect ownership relationships. Unlike the previous studies, we explicitly describe and publish the database structure and queries needed for the analysis of media ownership structures. Furthermore, we also present queries needed to search for indirect ownership relationships.

Media ownership relations form complex networks, and different methods and techniques are needed for their analysis (Birkinbine & Gómez 2020; Gómez & Birkinbine, 2024). Graph theory serves as a theoretical framework to model and manipulate different kinds of networks. Gómez and Birkinbine (2024) applied graph theory to measure the concentration of media corporations by utilising the connectivity of a graph and the degree of nodes to indicate and measure media concentration. Our approach is also based on the graph theory. Path analyses and the aggregation of relationship properties (edges) play the main role in uncovering non-transparent connections in media ownership. Although our approach is graph-based, we implement the graph of ownership structures in a relational database.

3. Structure of Ownership

The structure of outlet ownership comprises outlets, owners (shareholders), and the relationships among them. An owner can either be a natural or a legal person. Typically, a legal entity is a company that owns outlets or other companies. In practice, an outlet is always directly owned by one company. Other companies and/or natural persons then, in turn, own this company. If an owner is a company, it has its particular owners. Finally, the owners of the company — the shareholders — are either natural persons or foundations. This means that an ownership chain usually starts from a natural person and ends with an outlet via one or several legal persons.

From the data structure perspective, the ownership structure is a directed graph. Formally, a graph is a pair (V, E), where V is a set of vertices (nodes) and E is a set of edges. In the ownership structure, V consists of owners and outlets, whereas E represent direct ownership relationships between an outlet and owner or between two owners. In a directed graph, an edge possesses a start and end node. A start node represents a natural or legal owner, whereas the end node represents a legal owner or outlet. A directed edge from the start node v1 to the end node v2 can be represented as (v1 → v2) when only one edge can exist between these nodes. In the ownership structure, this means that v1 is a direct owner of v2. A (directed) path in a graph is a unique sequence of nodes (v1, v2, ..., vn) where v1, ..., vn ϵ V, and for all vi (i ϵ {1, ..., n-1}) there exists the edge (vi → vi+1) in E. The length of the path is the number of edges it involves. If the ownership structure contains a path from v1 to vn such that the length of the path is more than 1, v1 is an indirect owner of vn; that is, v1 owns vn via one or more legal owners.

In a property graph, nodes and edges may contain properties (Angles & Gutierrez, 2008). In the ownership structure, nodes have different properties depending on their types. Name, country, editors, and so forth are properties of outlets. Natural owners involve county, first name and last name. A legal person has a name, VAT number, country, and so forth. The properties of edges describe the properties of ownership relationships, such as the number of votes and amount of shares (AoS). In the present paper, we observe only those properties that are essential for demonstrating the manipulation of the ownership structure. Thus, the AoS is the only property of edges we consider. If x and y are owners and (x → y) ϵ E, then the edge contains a property that denotes the AoS. Below, this is denoted using the dot notation (x → y).AoS. Now, if there is a path (v1, v2, ..., vn), that is, v1 is an indirect owner of vn, the AoS based on this path can be calculated as follows:

$$\prod_{i=1}^{n-1}(v_i \rightarrow v_{i+1}).AoS \quad (1)$$

It is worth noting that v_1 may own v_n via several paths. Therefore, the AoS of different paths must be summed as follows:

$$\sum_{p\in(V,E)}\prod_{i=1}^{n-1}(v_i \rightarrow v_{i+1}).AoS\colon p=(v_1,\dots,v_n) \quad (2),$$

where p ϵ (V, E) means that p can be generated from the graph (V, E).

In general, graph theory serves as a powerful approach to analysing the ownership structure. Let us assume that x is a natural person and y is an outlet. Now, it is possible to find all outlets that x owns through paths that are started from x and calculate the total number of shares as shown above. In turn, it is possible to find all the owners of the outlet y and calculate their number of shares. Further, it is possible to analyse whether two or more natural or legal persons share ownership of the same outlets.

From now on, we will not use graph theoretic notations, but the graph will be modelled and stored in the relational database. In the database, there are separate tables for owners and outlets because they have different properties. Similarly, edges are distributed into two different tables. Before presenting the database solution, we introduce the sample ownership structure used throughout the paper.

A fictional sample ownership structure for illustrative purposes is provided in Figure 1. For example, Diana Palmer owns 80% of Phantom Co and Kit Walker 20%. Phantom Co owns 100% of Jungle Media Co, that is, the direct owner of *Jungle Magazine* and Jungle TV. A person may own a company through several ownership chains. For example, Kit Walker owns Bangalla Media via Phantom Co and Cave Co. Thus, when analysing ownership structures, various ownership chains must be considered.

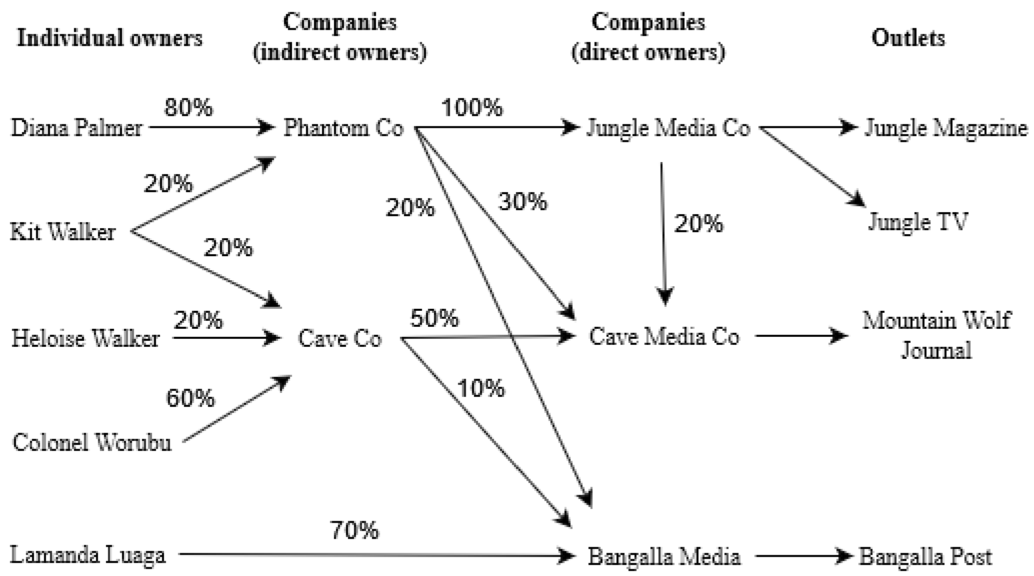

Figure 1. *Sample ownership structure*

An ownership structure can be composed of facts, each representing a single ownership relationship. The facts related to the sample structure are:

- Diana Palmer owns 80 % of Phantom Co
- Kit Walker owns 20 % of Phantom Co
- Kit Walker owns 20 % of Cave Co
- Heloise Walker owns 20% of Cave Co
- Colonel Worubu owns 60% of Cave Co
- Lamanda Luaga owns 70% of Bangalla Media Co
- Phantom Co owns 100% of Jungle Media Co
- Phantom Co owns 30% of Cave Media Co
- Phantom Co owns 20 % of Bangalla Media Co
- Cave Co owns 50% of Cave Media Co
- Cave Co owns 10% of Bangalla Media
- Jungle Media Co owns 20% of Cave Media Co

- Jungle Media Co owns *Jungle Magazine*
- Jungle Media Co owns Jungle TV
- Cave Media Co owns *Mountain Wolf Journal*
- Bangalla Media owns *Bangalla Post*

Above, we gave the sample ownership structure where natural and legal owners are nodes and edges are based on facts. The sample database is based on the corresponding data. The database enables the derivation and analysis of the ownership structure through database queries.

4. Database

In this section, we investigate how an ownership structure can be implemented in a relation database. The relational database consists of relations (tables) where attributes determine the columns of the table. An attribute may have a primary key (PK) role, which means that the values of the attribute identify the rows. A foreign key (FK) refers to the key of another table; that is, in terms of FK references, the relationships between entities can be represented. Conceptually, a table represents an entity or a relationship. Related to the ownership graph, tables can represent both nodes and edges. The database schema represents the structure of a database.

Figure 2 contains the database schema for the sample ownership structure. There are four tables: "Outlets", "Owners", "Outlet_owning", and "Owner_owning".

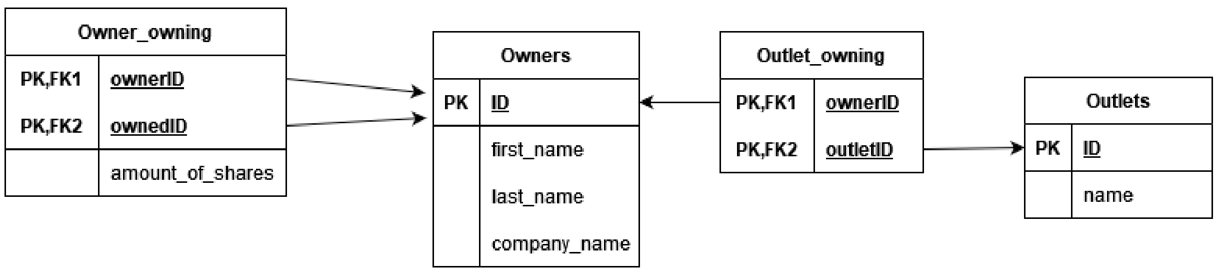

Figure 2. *Database schema*

The "Outlets" table contains attributes that describe the properties of outlets. We present only those attributes that are relevant to the present paper. The ID attribute is the PK, which means that it is the unique identifier for an outlet. The name of the outlet is the other attribute needed in this study.

The "Owners" table contains the attributes ID, first_name, last_name and company_name. ID is the PK of the owners. An owner may be a person when (s)he involves the first and last name, but the company name has a null value. If the owner is a company, then it has the company name, but the first and last names are null.

The "Outlet_owning" table contains two FKs that refer to other tables. OwnerID is the identity of owners referring to the "Owners" table, whereas outletID refers to the identity of an outlet. OwnerID and outletID together form the PK of the table.

Indirect ownership of outlets is manipulated via the "Owner_owning" table. It has the identities of the owner and owned entity, which both refer to the "Owners" table. In practice, an owner may be a company or person, but owned may not be a person. The table has the attribute amount_of_shares. The "Owner_owning" table may involve a long owning chain represented step by step. For example, if the length of an owning chain is four, then the "Owner_owning" table contains four rows, each representing one step in this chain.

In order to demonstrate ownership of outlets, we give the data of the sample ownership structure in Table 1, Table 2, Table 3, and Table 4.

Owners			
ID	first_name	last_name	company_name
1	Diana	Palmer	
2	Kit	Walker	
3	Heloise	Walker	
4	Colonel	Worubu	
5	Lamanda	Luaga	
6			Phantom Co
7			Jungle Media Co
8			Cave Co
9			Cave Media Co
10			Bangalla Media

Table 1. *The content of the "Owners" table*

Outlets	
ID	name
1	*Jungle Magazine*
2	Jungle TV
3	*Mountain Wolf Journal*
4	*Bangalla Post*

Table 2. *The content of the "Outlets" table*

Outlet_owning	
ownerID	outletID
7	1
7	2
9	3
10	4

Table 3. *The content of the "Outlet_owning" table*

Owner_owning		
ownerID	ownedID	amount_of_shares
1	6	0.8
2	6	0.2
2	8	0.2
3	8	0.2
4	8	0.6
5	10	0.7
6	7	1
6	9	0.3
6	10	0.2
8	9	0.5
8	10	0.1
7	9	0.2

Table 4. *The content of the "Owner_owning" table*

As shown above, the data is stored in tables where FK references determine the relationships between entities. For example, the first row (7, 1) in the "Outlet_owning" table means that the owner with id 7 (Jungle Media Co) owns the outlet with id 1 (*Jungle Magazine*). These references are utilised in database queries.

5. Database Queries

In this section, we introduce analysis capacities that SQL serves for ownership structures. SQL is the de facto standard query language for relational databases. Its basic form uses tree blocks (Chamberlin & Boyce, 1974). In the SELECT block, the returned attributes of the query are specified. The FROM block determines the tables to which the query is directed. In the WHERE block, the conditions of the query are presented.

For example, in Query 1, the SELECT block determines that the name of an owner is returned. The query is directed to three tables. In the WHERE block, the name of the outlet is specified. Then, the identity (3) of the outlet is matched with the corresponding identity in the "Outlet_owning" table. Finally, the owner identity (9) is matched with the "Outlet_owning" table. The result of the query is Cave Media Co.

Query 1. Who owns *Mountain Wolf Journal*?

```
SELECT Owners.company_name
FROM Outlets, Outlet_owning, Owners
WHERE Outlets.name = 'Mountain Wolf Journal'
    AND Outlets.ID = Outlet_owning.outletID
    AND Owners.ID = Outlet_owning.ownerID;
```

In Query 2, the shareholders of the owner of the *Mountain Wolf Journal* with the AoS are searched. This query is directed to all tables of the database. Furthermore, there are two shareholders to be manipulated. These can be distinguished by aliases owner1 and owner2. Aliases can also be used in the SELECT block. For example, owner2.name AS owner_of_MWJ determines that the result column is labelled by owner_of_MWJ instead of owner2.name. The WHERE block contains the same conditions as Query 1, but the ownership relationships between owner1 and owner2 must also be specified.

Query 2. Who owns the company that *Mountain Wolf Journal* owns?

```
SELECT owner2.company_name AS owner_of_MWJ,
    Owner_owning.amount_of_shares AS share
FROM Outlets, Outlet_owning, Owner_owning, Owners AS owner1,
    Owners AS owner2
WHERE Outlets.name = 'Mountain Wolf Journal'
    AND Outlets.ID = Outlet_owning.outletID
    AND Outlet_owning.ownerID = owner1.ID
    AND Owner_owning.ownedID = owner1.ID
    AND Owner_owning.ownerID = owner2.ID;
```

The result of the query is given in Table 5.

owner_of_MWJ	share
Phantom Co	0.3
Cave Co	0.5
Jungle Media Co	0.2

Table 5. *The result of Query 2*

Queries 3–5 aim to search the number of media company shares owned by natural persons. Query 3 searches the companies and the AoS that Kit Walker owns. Now, owners have an owner and owned roles.

Query 3. What does Kit Walker own?

```
SELECT owned.company_name AS Kits_company,
    Owner_owning.amount_of_shares AS share
FROM Owners AS owner, Owners AS owned, Owner_owning
WHERE owner.first_name = 'Kit' AND owner.last_name = 'Walker'
    AND Owner_owning.ownerID = owner.ID
    AND Owner_owning.ownedID = owned.ID;
```

The result of the query is given in Table 6.

Kits_company	share
Phantom Co	0.2
Cave Co	0.2

Table 6. *The result of Query 3*

Next, we are seeking all companies that one Walker owns through another company. The result will contain the full name of the Walker, the name of the companies that (s)he owns directly, the name of companies that these companies own and derived ownership amount. The derived amount of share is the product of the AoS in an ownership chain. For example, Heloise Walker owns 10% of Cave Media Co because she owns 20% of Cave Co and Cave Co owns 50% of Cave Media Oy.

In the related SQL query, several aliases are needed. The alias owner is a natural person whose last name is Walker. The alias owned1 is a company that the natural person owns directly. The alias owned2 is a company that is owned by owned1. Further, two instances of the "Owner_owning" table are needed. The alias owning1 refers to the ownership between a natural person and a company, whereas owning2 refers to the ownership relationship between two companies. The total share is calculated through the production of AoS.

Query 4. What are the companies that a Walker owns via another company?

```
SELECT owner.first_name AS fname, owner.last_name AS lname,
    owned1.company_name AS first_company,
    owned2.company_name AS second_company,
    owning1.amount_of_shares * owning2.amount_of_shares AS total_share
FROM Owners AS owner, Owners AS owned1, Owners AS owned2,
    Owner_owning AS owning1, Owner_owning AS owning2
WHERE Owner.Last_name = 'Walker'
    AND owner.id = owning1.ownerID
    AND owned1.id = owning1.ownedID
    AND owned1.id = owning2.ownerID
    AND owned2.id = owning2.ownedID;
```

The result is shown in Table 7.

fname	lname	first_company	Second_company	total_share
Kit	Walker	Phantom Co	Jungle Media Co	0.2
Kit	Walker	Phantom Co	Cave Media Co	0.06
Kit	Walker	Phantom Co	Bangalla Media	0.04
Kit	Walker	Cave Co	Cave Media Co	0.1
Kit	Walker	Cave Co	Bangalla Media	0.02
Heloise	Walker	Cave Co	Cave Media Co	0.1
Heloise	Walker	Cave Co	Bangalla Media	0.02

Table 7. *The result of Query 4*

The result of Query 4 shows that Kit Walker owns Cave Media CO and Bangalla Media via two companies. Thus, the whole ownership of these structures should be summed up when one is interested in the total ownership of companies. In terms of the GROUP BY operation, it is possible to determine how values are aggregated. Query 5 demonstrates how values can be summed based on the grouping of entities. The grouping is based on the owners' identity.

Query 5. Summed company ownerships.

```
SELECT owner1.first_name AS fname, owner1.last_name AS lname,
    owned2.company_name AS second_company,
    SUM(owning1.amount_of_shares * owning2.amount_of_shares) AS total_share
FROM Owners AS owner1, Owners AS owned1, owners AS owned2,
  Owner_owning AS owning1, Owner_owning AS owning2
WHERE owner1.last_name = 'Walker'
  AND owner1.id = owning1.ownerID AND owned1.id = owning1.ownedID
  AND owned1.id = owning2.ownerID AND owned2.id = owning2.ownedID
GROUP BY owner1.first_name, owner1.last_name, owned2.company_name;
```

The result is shown in Table 8.

FNAME	LNAME	SECOND_COMPANY	TOTAL_SHARE
Kit	Walker	Jungle Media Co	0.2
Kit	Walker	Cave Media Co	0.16
Kit	Walker	Bangalla Media	0.06
Heloise	Walker	Cave Media Co	0.1
Heloise	Walker	Bangalla Media	0.02

Table 8. *The result of Query 5*

The queries above are based on ownership chains with a specific length. However, the total ownership may be based on ownership chains with various lengths. For them, recursive queries are needed. In a recursive query, a contemporary table consisting of transitive relationships is first formed. This involves two parts. The first part installs the table by a single relationship. The second part seeks new connections step by step until all the relationships have been gone through. Based on the contemporary table, an actual query can be formed.

Query 6 is a recursive query for specifying the ownership structure of an outlet. The sample outlet is *Mountain Wolf Journal* with identity 3. In terms of the WITH command, a contemporary table (sub-owners) is created. In the first SELECT part, the direct owner of *Mountain Wolf Journal* and its direct owner (Cave Media Co) are searched. Then, the owners of Cave Media Co are specified. These have owner identities 6–8. The depth is 1, which means that this is the first level of ownership. Thus, the first SELECT part produces the table that contains rows (6, 4, 1), (7, 4, 1) and (8, 4, 1).

The next command is UNION, which means that the second SELECT clause is added to the first part. The second SELECT block is the actual recursive part of the query, and it updates the contemporary table at a hierarchy level at a time. The depth attribute is updated at each hierarchy level.

Finally, the contemporary table is used to specify the actual result.

Query 6. Recursive query: all owners of *Mountain Wolf Journal*.

```
WITH RECURSIVE sub-owners AS
    (SELECT Owner_owning.ownerID, Owner_owning.ownedID, 1 AS depth
    FROM Owner_owning, Outlet_owning
    WHERE Outlet_owning.outletID = 3
    AND Outlet_owning.ownerID = Owner_owning.ownedID
UNION
    SELECT co.ownerID, co.ownedID, s.depth+1
    FROM Owner_owning AS co, sub-owners s
    WHERE s.ownerID = co.ownedID AND depth < 10)
SELECT DISTINCT owner.first_name AS fname, owner.last_name AS lname,
    owner.company_name AS owner_company,
    owned.company_name AS owned_company, depth
FROM sub-owners, Owners AS owner, Owners AS owned
WHERE sub-owners.ownerID = owner.ID AND sub-owners.ownedID = owned.ID
ORDER BY depth;
```

The result is shown in Table 9.

FNAME	LNAME	OWNER_COMPANY	OWNED_COMPANY	DEPTH
		Phantom Co	Cave Media Co	1
		Cave Co	Cave Media Co	1
		Jungle Media Co	Cave Media Co	1
Diana	Palmer		Phantom Co	2
Kit	Walker		Phantom Co	2
Kit	Walker		Cave Co	2
Heloise	Walker		Cave Co	2
Colonel	Worubu		Cave Co	2
		Phantom Co	Jungle Media Co	2
Diana	Palmer		Phantom Co	3
Kit	Walker		Phantom Co	3

Table 9. *The result of Query 6*

In the result of the query, the depth column is interpreted such that if it is 1, then the owned company is the direct owner of *Mountain Wolf Journal*. Depth 2 refers to owners on the next hierarchy level. At this level, there is one legal person and several natural persons. Depth 3 refers to the longest ownership chain in the example. It is worth noting that Phantom Co owns Cave Co directly and via Jungle Media Co. Thus, it has two depth values, and Diana and Kit have two references to Phantom Media.

The AoS could be inserted in Query 6, but the query does not support the presentation of total ownership of shares. Query 7 is focused on aggregating them between natural persons and outlets. The query hides the ownership structure, and it shows natural persons, outlets they own and the total AoS, which is formed from several ownership chains. For example, the total AoS of Kit Walker for *Mountain Wolf Journal* is 20%. This is the sum of three ownership chains. From the chain Kit Walker → Phantom Co → Jungle Media Co → Cave Media Co, the calculated AoS is 4%. Based on the chain: Kit Walker → Phantom Co → Cave Media Co, the value is 6%. The chain Kit Walker → Cave Co → Cave Media Co produces 10%. Thus, the total ownership of Kit Walker from *Mountain Wolf Journal* is 20%.

Query 7 is a recursive query for calculating the total ownership shares of outlets by natural persons. In the query, the contemporary table sub-share is first installed by direct ownership relationships of natural persons. They can be found because they do not have any company name. In the recursive part, all the relationships are browsed step by step, and the product operation calculates the amounts of shares. Finally, the sub-share table contains all direct and indirect ownership relationships of natural persons with the derived AoS. From the companies, the direct owners of outlets are filtered, and the related outlets are joined to them. Because one person may own an outlet via various ownership chains, these are grouped, and AoS are aggregated.

Query 7. Aggregated media ownership of natural persons.

```
WITH RECURSIVE sub-share AS
    (SELECT Owner_owning.ownerID AS owner, Owner_owning.ownedID AS owned,
   Owner_owning.amount_of_shares AS share, 1 AS depth
    FROM Owners, Owner_owning
    WHERE Owners.company_name IS NULL AND Owner_owning.ownerID = Owners.ID
UNION
    SELECT sub-share.owner, Owner_owning.ownedID,
    CAST((Owner_owning.amount_of_shares*sub-share.share) AS numeric(9,8)),
  depth+1
    FROM Owner_owning, sub-share
    WHERE sub-share.owned = Owner_owning.ownerID AND depth < 10)
SELECT DISTINCT Owners.first_name AS fname, Owners.last_name AS lname, Outlets.name AS outlet, SUM(sub-share.share) AS "total share"
FROM sub-share, Owners, Outlets, Outlet_owning
WHERE Owners.ID = sub-share.owner AND sub-share.owned = Outlet_owning.ownerID
    AND Outlets.ID = Outlet_owning.outletID
GROUP BY Owners.first_name, Owners.last_name, Outlets.name;
```

The result of Query 7 is given in Table 10.

FNAME	LNAME	OUTLET	TOTAL SHARE
Diana	Palmer	*Jungle Magazine*	0.8
Diana	Palmer	Jungle TV	0.8
Diana	Palmer	*Mountain Wolf Journal*	0.4
Diana	Palmer	*Bangalla Post*	0.16
Kit	Walker	*Jungle Magazine*	0.2
Kit	Walker	Jungle TV	0.2
Kit	Walker	*Mountain Wolf Journal*	0.2
Kit	Walker	*Bangalla Post*	0.06
Heloise	Walker	*Mountain Wolf Journal*	0.1
Heloise	Walker	*Bangalla Post*	0.02
Coloney	Worabu	*Mountain Wolf Journal*	0.3
Coloney	Worabu	*Bangalla Post*	0.06
Lamanda	Luaga	*Bangalla Post*	0.7

Table 10. *Result of Query 7*

As shown above, recursive queries can be used to derive a hierarchical ownership structure, to find indirect ownership relationships, and to calculate relative ownership shares. However, the problem with a hierarchical representation is that there may be cycles in the ownership structure that distort ownership relationships. Namely, the hierarchy becomes infinite. This is not just a problem of the relational model but is related to any hierarchical representation of graphs. In Queries 6 and 7, there is a condition (depth > 10) that allows ownership chains of up to 10 lengths, and no infinite structure can be created. This is the usual way to avoid endless processing.

Query 7 works well, although there would be cycles in the ownership structure. Let the situation of Figure 3 illustrate the cross-ownership problem. In it, a natural owner, X, owns 50% of the companies A and B. Further, A owns 50% of B, and B owns 50% of A. In practice, X owns 100% of A and B. However, it seems that X owns 75% of B (also of A) because s(he) owns 50% directly and 25% through A. This is a total of 75%. The rest 25% is hidden in the cross-ownership cycle. This can be made transparent by taking several rounds in the loop. For example, in the three-step owning chain X → B → A → B the AoS is 0.5*0.5*0.5 = 0.125. When taking all the chains into account, the total share is 100%. Query 7 contains a limitation of 10 steps. This gives quite a good approximate value of 99.9%. Table 11 contains the values which are calculated related to each owning chain used in the calculation. Unlike other tables, Table 11 is not a database table or the result of a query. The related query would produce two rows: (X, Outlet1, 0.99902343) and (X, Outlet2, 0.99902343).

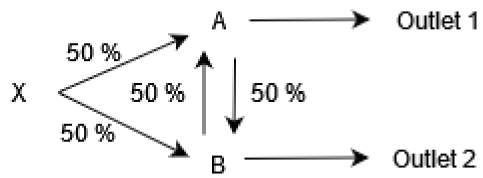

Figure 3. *Cross-ownership relationships in the* EurOMo *database*

Ownership chain	steps	Shares
x-b	1	0.5
x-a-b	2	0.25
x-b-a-b	3	0.125
x-a-b-a-b	4	0.0625
x-b-a-b-a-b	5	0.03125
x-a-b-a-b-a-b	6	0.015625
x-b-a-b-a-b-a-b	7	0.0078125
x-a-b-a-b-a-b-a-b	8	0.00390625
x-b-a-b-a-b-a-b-a-b	9	0.00195313
x-a-b-a-b-a-b-a-b-a-b	10	0.00097656
Total amount of shares		0.99902343

Table 11. *Total ownership in a cross-ownership case*

If a more precise AoS in the cross-ownership chain is needed, Query 7 can be modified so that the limit condition value is bigger. A bigger value is also needed when an ownership cycle contains several legal owners or long ownership chains. In the *EurOMo 1* project, cyclic owning structures were found in six out of 15 countries. Typically, a cycle consists of two or three members, but some cross-owning structures are very complex. *EurOMo 1* was a pilot project that did not contain all media-owning relationships.

We have formulated seven queries to explore direct and indirect outlet ownership relationships. The first two queries are intended to find the first- and second-level owners of an outlet. Respectively, Queries 3 and 4 search the first and second levels of ownership of a natural person. Query 5 demonstrates how the AoS can be derived from paths having length 2. In the rest of the queries, no path length is specified. This means that recursive queries are needed. Query 6 finds all owners of a journal. The result contains both natural and legal owners. Furthermore, the depth of ownership is attached to the query results. Query 7 connects natural persons to the outlets they own with the derived AoS. First, the query is applied to the running example where no cycle exists. Then, the query is applied to a cross-ownership situation, and the challenges that this causes in calculating the total AoS are discussed.

6. Discussion

The presented database structure is simplified and does not support all aspects of transparency. Staying up to date is one of these factors. Similarly, the source of information is essential for verifying perspective. The database itself is as up-to-date as its most recent update. In order to ensure it is up-to-date, each entity and relationship can be accompanied by metadata indicating when it was last updated, facilitating easy revision. This can be implemented with a separate table where the source and the date are expressed. Figure 4 shows the expanded database where the source is marked. In connection with searches, the newest information can be selected, or the result can be filtered based on its age. For example, the recursive queries could be formulated in such a way as to include the newest date found in the chain of ownership. This also indicates the timeliness of the entire ownership chain.

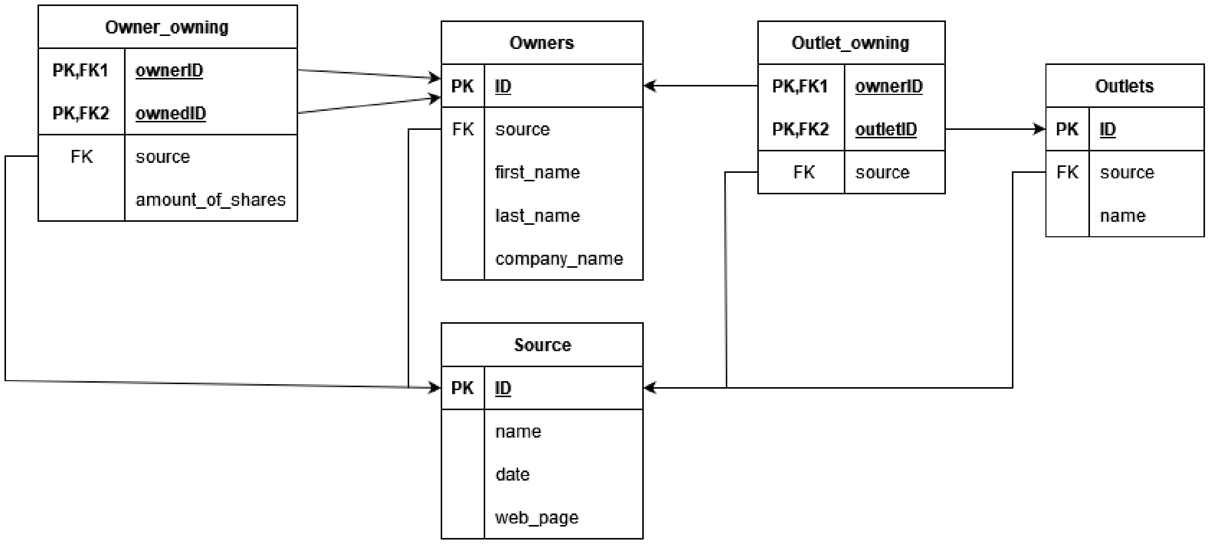

Figure 4. *Adding sources to the database*

Family ownership has been seen as a problem with the position of transparency because the family may form a stable interest group. From the point of view of databases, these can be analysed and formed into groups that indicate the total ownership of families. Technically, this means that a new table with two references to the owner table is inserted in the database.

Consider the example where Diana Palmer is associated/married to Kit Walker in the context of a family, with Heloise being their daughter, thus forming a familial relationship. The kinship table would have this information in three lines. Now, a query can be conducted in the database, which groups ownership by family and aggregates ownership relationships. In this case, a scoreboard could be formed according to Table 12, which indicates the families' holdings in different outlets.

FAMILY	OUTLET	TOTAL_SHARE
Walkers	*Jungle Magazine*	1
Walkers	Jungle TV	1
Walkers	*Mountain Wolf Journal*	0.7
Walkers	*Bangalla Post*	0.24

Table 12. *Family ownership*

Analysis of family relationships may be limited by national legislation. Even if family relations are public, their publication in an open database may be limited.

Sometimes, companies may buy back their own shares from the public market to reward their shareholders without paying any dividends (Mallika et al., 2024). In this case, the FKs of the "Owner_owning" table have the same value. In other words, the attributes ownerID and ownedID have identical values. Query 7 can be used similarly to cross-ownership situations.

SQL also enables the analysis of database coverage. For example, one might ask how much of the ownership of the media is stored in the database. In the example database, the holdings of all outlets are fully known; that is, they are accompanied by a ratio of 1. There are no media in the example and no owners from different countries. Nor are they marked in the structure of the database. If country-specific information is added to the database structure, it would be possible to compare how comprehensively ownership relationships are stored in the database in different countries. In this case, it would also be possible to analyse ownership chains that cross borders.

The structure presented has been used to implement the *EurOMo* database using the PostgreSQL database (https://www.postgresql.org/). Relations naturally have more attributes than in the example (see Euromedia Ownership Monitor, n.d.). In addition, the database contains tables that describe in more detail the type of media as well as country-specific location information. The sources discussed above are also described in the database. Similarly, the structure includes the possibility of describing kinship relations, although it was not implemented in the *EurOMo* project. The *EurOMo* application does not contain an open SQL interface, but it has predefined queries hidden behind the web interface. Transitive processing is limited to Query 6, like presentations, where the user can search for ownership relationships starting with the owner or the outlet. On the other hand, direct proportional ownership such as Query 7 was not implemented in *EurOMo*, even if the structure of the database had made it possible.

7. Conclusions

The main reason why transparency of ownership matters is that without comprehensive data about ownership relationships — both direct and indirect — it is impossible to reliably evaluate the diversity of market structure and the degree of ownership concentration. This is crucial, especially when analysing media and communication industries because diverse and competitive news media markets are essential for a functioning democracy. While network analysis provides new tools for political economy research for illustrating and measuring the ownership concentration (Birkinbine & Gómez, 2020; Gómez & Birkinbine, 2024), the outcome is always just as good quality as the search results of the data, which analysis is based.

This is because the true degree of ownership concentration can be hidden by using indirect ownership relationships. First, figuring out long ownership chains is difficult. In this case, the share of ownership is also obscured because the total share must be calculated as the product of several shares of ownership. A more difficult situation is when the ownership is directed along several paths. In this case, you must first determine the share of ownership determined by each path and then add up the ownership ratios of the paths. There can also be loops in the ownership structure, which means that the ownership relationships cross. In this case, the actual ownership relationship may become even more obscured because an infinite number of different ownership paths are generated. However, a structured database and an advanced query approach can be used to overcome these problems, improve the quality of the search results and complement other methods of analysis. Additionally, a structured database and an advanced query approach can be used to identify cross-border media ownership relationships and evaluate media ownership by multinational investment companies at a global level.

We introduced the database structure and the database queries that can be used to solve these problems. Database queries are not intended to be managed by the end user, but a search system can be implemented based on them, where the user defines the search type and provides the necessary parameters for the search. Some of the search methods presented in this paper were implemented in the *EurOMo* project. However, the database structure and the queries are general and do not bind to any specific dataset.

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