DESIGN OF A FINANCIAL DATABASE FOR STORING FINANCIAL STATEMENTS' DATA

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Abstract

In today's highly competitive world, the pursuit of accurate, on-time, up-to-date, and complete information has become a cornerstone of the business's success. By gathering and organizing structured and relevant data, different by their nature, origin, volume, and scope, databases remain to be a valuable and trustworthy source of information in many areas. In the sphere of financial management, financial databases play a key role not only in evaluating the financial health of a business and in analyzing a business's performance but also in research and financial modeling. The paper aims to propose a generic relational database design suitable for the acquisition of relevant data about financial statements of business subjects based on the relational data model and using the methodology of designing relational databases, including the first two phases: the conceptual and the logical design. The physically implemented database can provide a solid platform for organizing, storing, processing, and retrieving valuable financial information using SQL scripts.

Keywords: financial data, financial statements, relational databases, E-R diagram, relational schema.

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1. Introduction

Providing accurate, comprehensive, and up-to-date information on time is of the utmost importance and highest priority in today's digitalized business environment. The complex processes of globalization, the increased competition, and the amplified uncertainties impose the necessity of using large amounts of information to determine the business entities' policy of development. A significant portion of such information comes from financial statements, which provide a realistic and objective picture of a company's business condition (Zager & Zager, 2006). The information presented in financial statements allows one to see the state of financial assets, sources of funds, income, expenses, and the overall business result and, based on this information, to make reasoned decisions to use production factors more efficiently and achieve better business results.

The set of the three major financial statements that represent a legal obligation for both commercial and financial firms consists of (1) an Income statement (also known as a Profit & Loss statement), (2) a Balance Sheet, and (3) a Cash Flow statement. Since all of these statements allow the identification of the problems and difficulties faced by business entities, they help in finding appropriate solutions to overcome them and to take measures to improve the results of operations. As such, they remain one of the fundamental sources of information about an actual firm's business health, which both internal and external users are interested in. By representing active instruments of the business policy of companies, they remain a solid basis for making realistic and adequate business decisions, and also a key factor in improving business operations.

Recognizing the immense value of information held within financial statements and other financial instruments, the need for efficient organizing and storing of relevant financial data has led to the emergence of financial databases. Financial databases enable sophisticated analysis across a broad range of financial instruments and wide-ranging, complete statistics. Such comprehensive historical numerical data can deliver top-quality research and analytical products to be used by the global financial services marketplace. Financial data management using financial databases allows companies to provide access to all stakeholders in the organization to perform financial analyses they need, on-demand. Moreover, allowing users the ability to create their financial models using financial databases results in better insights, faster results, and more profound outcomes. In this context, the paper aims at proposing a database design of a generic financial micro-database suitable for keeping and retrieving financial statements' data.

The paper is structured as follows. Section 2 elaborates on the recent research made on financial databases. The next section focuses on the

meaning, structure, and goals to be achieved by using financial databases in the contemporary business environment. In Section 4, the authors present the sources of data and methodology used. The process of designing a generic financial database for the acquisition of financial statements is being elaborated in Section 5, in two sub-phases: construction of an Entity-Relationship diagram as a constituent part of the conceptual design (Subsection 5.1) and mapping it into a corresponding relational database schema, also known as logical design (Subsection 5.2). The last section concludes.

2. Related Research

During the last two decades, due to their increasing importance, financial databases have been put in focus and correspondingly, they have become a subject of continuous research. In this section, some of the most prominent research work made on this topic is being elaborated on.

In 2000 Beck, Demirgüç-Kunt, & Levine introduced a new database, encompassing indicators of financial structure and financial development across countries over time. Compared to previously introduced databases, it was quite distinctive since it combined a wide variety of indicators that measure the size, activity, and efficiency of financial intermediaries and markets, including indicators of the size and activity of non-bank financial institutions and measures of the size of bond and primary equity markets. Their work describes the sources, the construction, and the rationale behind the different indicators included in the database (Beck, Demirgüç-Kunt, & Levine, 2000).

The work of Abiad, Detragiache, & Tressel (2008) focuses on the introduction of a new database of financial reforms, covering 91 economies from 1973 to 2005. By describing the content of the database, the information sources utilized, and the coding rules used to create an index of financial reform, the paper also compares the proposed database with other measures of financial liberalization, provides descriptive statistics, and discusses some possible applications. The database provides a multi-faceted measure of financial reform, covering seven aspects of financial sector policy.

In 2011, Isac, Isac, & Guţă elaborated on the e-Finance software application for online submission and tracking of semi-annual and annual financial statements and fiscal declarations, using MySQL RDBMS and PHP (Isac, Isac, & Guţă, 2011).

Sequeira, Pai, & Surekha (2012) reported on the development of a special-purpose Management Information System in organizations, the Financial Management Information System (FMIS), based on the utilization of

a corresponding financial database implemented in Oracle 9i DBMS, to improve the system's functions, performance, and productivity.

In their work, Olbrys & Majewska (2014) present various empirical problems concerning financial databases, pointing out the data accuracy and the availability of high-quality data as crucial factors for all those who use such databases.

Recognizing the necessity and the importance of rigorous and proper linking of financial databases, the research made by Rodriguez-Lujan & Huerta (2014) proposes a machine learning (ML) solution to solve the problem of matching heterogeneous financial databases in two stages: schema matching and entity matching, based on the utilization of the newly introduced Financial Attribute Selection Distance (FASD) method developed on the Kullback-Leibler divergence of string and numeric attributes.

Pierson, Hand, & Thompson (2015) point out the problem of limited research due to the absence of a common public financial database for empirical analysis. Because the difficult process of collecting, interpreting, and organizing the public financial data has made its adoption to be prohibitive and inconsistent, they offer a single, coherent resource that contains all of the government financial data for the period 1967–2012.

Recognizing the fact that tackling financial flows between countries relies on the availability of coherent and consistent data along with up-to-date information, Nardo *et al*. (2017) propose the usage of a database as a repository to share data that can be found in different sources and propose a methodology to build a symmetrical matrix about bilateral financial flows.

The paper of Sabol (2019) lists the contents of the Capital Markets Data Project monthly database, CMD-MD, which contains 367 series/columns centered around the capital markets, suitable for performing research on a macro-financial level.

3. The Five W's and One H of Financial Databases

Financial databases consist of financial data, i.e. pieces or sets of information (datasets) related to the financial health of a business. These pieces of data are usually used by internal management to analyze business performance and determine whether tactics and strategies must be altered. When financial data go public, people and organizations outside a business can also use financial data reported by the business to judge its creditworthiness, decide whether to invest in the business and determine whether the business is complying with government regulations.

Financial databases are specialist databases that provide very detailed current/historic financial information and/or aggregated data for a wide range of companies and financial market data items. Their scope can be on a local,

regional, national, international, and global level. Some of them cover macroeconomic data, whilst others deal with micro-socioeconomic data. The data is usually acquired in a form of monthly, quarterly, and annual time series, providing current and historical financial and economic information. Some of the financial databases reach up to 60 years of coverage in the past and/or include detailed information on thousands and even millions of public and private firms (both corporate and financial ones) in a huge number of countries. While some of them do require a level of programming expertise to extract the data, plenty of them offer user-friendly interfaces that allow one to search them easily by category, industry, country, region, history, delivery channel, delivery platform, and point-in-time, or sort the data by various criteria: geographic location, activity description, number of employees, financial statement items, ratios, credit score/rating, relevance, dataset column names, company names, recency, etc. Some of them allow data breakdowns by size classes of businesses (micro, small, medium, SMEs, large) and/or businesses' sectors (sections, divisions). Some of the financial databases are part of high-speed, high-performance information systems - Internet portals that offer online services to financial professionals, which deliver a potent combination of real-time information and powerful analysis tools *vis-à-vis* various financial categories. A great portion of them provides advanced user interfaces that offer easy-to-use pre-formatted charts and tabular reports with flexible charting to enable their users to uncover new and valuable insights.

When it comes to the data held within, these databases may include a vast variety of categories, starting from equities (prices, key financials (P/E, EPS, etc.), equity indices (trade value, prices, turnover, etc.), stock market indices, stocks, bonds (both corporate and government) and convertibles, bonds indices & CDS, securities, mutual funds/hedge funds/fund of funds, derivatives (warrants, futures, options), indices, currencies, trusts (both unit and investment trusts), interest rates (treasury bonds, state bonds, etc.), commodities, and company fundamentals, to fixed income securities and key economic indicators, including various economic indicators (macroeconomic time series from highly credible sources such as International Monetary Fund (IMF), Organization for Economic Co-operation and Development (OECD), European Central Bank (ECB), Eurostat, Economist Intelligence Unit (EIU), national statistical agencies, etc.).

Some of the biggest and most popular financial databases on a global level are the following ones (SGSB, 2012; PUL, 2022): *Bloomberg*, *Datastream*, *FactSet*, *CRSP (Center for Research in Securities Prices)*, *Global Financial Data*, *AMADEUS (Analyse MAjor Database from EUropean Sources)*, *S&P Capital IQ Pro*, *Compustat*, *Bankscope*, *Company Analysis*, *Eikon*, *FAME*, *Osiris*, *ProQuest Business*, *SNL Financials*, *CEIC*, *BoardEx*, etc.

Access to world-class financial databases is commercial and it is usually granted only to legal subscribers. Moreover, the charge for using such databases ranges from a couple of US$ per hour to several hundreds of US$ per month and even several tens of thousands of US$ per year, which the majority of their potential users can find quite expensive. This notion imposes the necessity for designing, implementing, and maintaining own financial micro-databases.

4. Data and Methodology

Since financial statements are the basis for carrying out financial analysis, which, as an extremely important process, involves specific techniques for evaluating risks, performance, financial health, and prospects of an organization to make better economic decisions and earn income in the future (White, Sondhi, & Fried, 2003), the paper focuses solely on the design of a financial database for organizing and storing data coming from this specific type of financial instruments. The data needed for modeling purposes during the preliminary phase of collecting facts have been extracted from secondary sources: the financial statements of Macedonian commercial firms listed by the Macedonian Stock Exchange (MSE), retrieved from the System for Electronic Information (SEI Net) (SEI, 2022). It should be notified that the financial statements' data of Macedonian financial firms have not been taken into account; in addition, there is some difference *vis-à-vis* specific positions in the financial statements between the two types of firms.

The designing process strictly follows the methodology of designing relational databases, including (1) the development of a conceptual data model (an E-R diagram using the original Chen notation) and (2) mapping the resulting E-R diagram into a corresponding relational schema of the database following the rules for obtaining the logical design directly from the conceptual one (Elmasri & Navathe, 2016, pp. 59–105; Elmasri & Navathe, 2016, pp. 289–306). Such an approach guarantees that all the relations will be at least in a Third Normal Form (3NF), which is *de facto* an industry standard. The E-R diagram has been constructed using the Microsoft® Visio® software package, however, many other designing tools, both online and on-premises, can be utilized for this task.

5. Designing a Financial Database from Scratch

This section elaborates on the process of designing a financial database suitable for storing financial statements going through the first two phases: the phase of conceptual modeling and the phase of logical design.

5.1 Conceptual Design

The overall conceptual design is quite straightforward and can be sublimed by the Entity-Relationship (E-R) diagram presented in Fig. 1, which was constructed following the principles of the conceptual database design given by Bagui & Earp (2011) and using the original Chen notation.

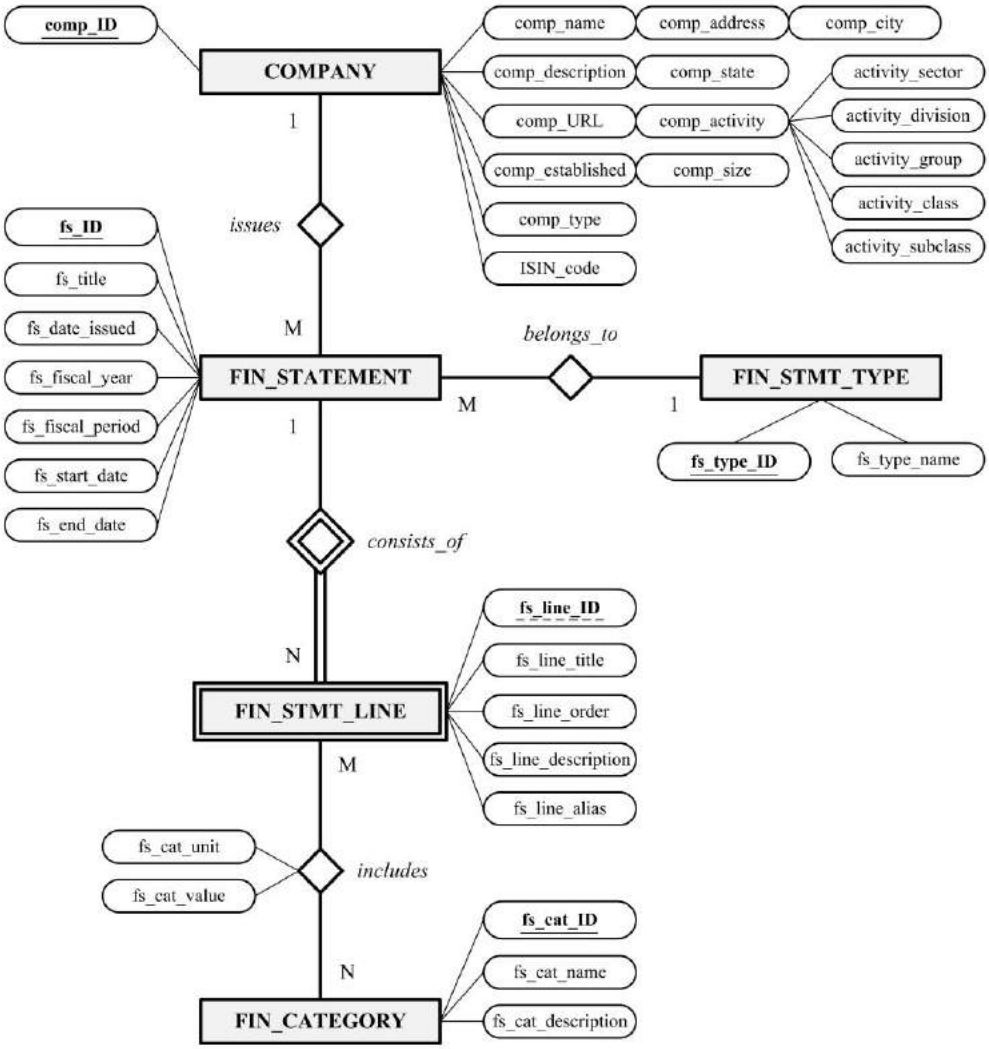

Figure 1. E-R diagram of the financial database suitable for storing financial statements

The E-R diagram depicted in Fig. 1 consists of four regular entity types and a single 'weak' entity type.

The entity type COMPANY, uniquely identified by the key attribute comp_ID, represents all the business entities that issue financial statements

and for which the financial database keeps records. The names of its non-key attributes are self-explainable, except for the following ones:

- *comp_type*, which refers to the type of the company (either commercial firm or financial firm);
- *ISIN_code*, which refers to the International Securities Identification Number, as defined by the ISO 6166 standard, is a 12-digit alphanumeric code that uniquely identifies specific security. The organization that allocates ISINs in any particular country is the country's respective National Numbering Agency (NNA);
- *comp_activity*, which refers to the primary activity of the company, as described by the National Classification of Activities - NKD Rev.2 (valid from January 01, 2013) (SSO, 2022). It is a composite attribute that can be divided into sub-parts: the attributes *activity_sector*, *activity_division*, *activity_group*, *activity_class*, and *activity_subclass*. The NKD Rev.2 Classification of Activities takes into account 21 sectors, 88 divisions, 272 groups, 615 classes, and 4 subclasses in total;
- *comp_size*, which refers to the size of the company (e.g. micro, small, medium, and large);

The entity type FIN_STMT_TYPE, identified by its key attribute fs_type_ID, represents the set of the three possible major financial statement types, e.g. Income Statement (Profit & Loss Statement), Balance Sheet, and Cash Flow Statement (possible values of the non-key attribute *fs_type_name*). If applicable, the fourth type of financial statement, named Statement of Changes in Equity, can be taken into account, as well.

The entity type FIN_STATEMENT, identified by its key attribute fs_ID, denotes all the financial statements. Any financial statement has its title (*fs_title*) and is issued on a specific date (*fs_date_issued*). It refers to a single fiscal year (*fs_fiscal_year*) and a given fiscal period (*fs_fiscal_period*), which spans from a starting date (*fs_start_date*) to an ending date (*fs_end_date*).

A company issues multiple financial statements, and each of them is issued by a specific company (binary relationship '*issues*' between entity types COMPANY and FIN_STATEMENT with a cardinality 1:M, mandatory on both sides). Each financial statement belongs to a specific type, and for each specific type, there are many financial statements (binary relationship '*belongs_to*' between entity types FIN_STATEMENT and FIN_STMT_TYPE with a cardinality M:1, mandatory on both sides).

Each financial statement consists of multiple lines, modeled by the 'weak' entity type FIN_STMT_LINE that is partially identified by its key attribute fs_line_ID. Each line is described by the attribute *fs_line_description*. If there are multiple names for the line, they are recorded in the attribute *fs_line_alias*. By *default*, the binary relationship '*consists_of*' between the

'strong' entity type FIN_STATEMENT and the 'weak' entity type FIN_STMT_LINE has a cardinality of 1:N and is mandatory on both sides.

All the financial categories included in the lines of a financial statement are represented by the entity type FIN_CATEGORY, exclusively identified by the key attribute fs_cat_ID. The non-key attribute *fs_cat_name* holds the name of the specific category (e.g. Total sales revenues, Revenues from the domestic market, Revenues from the foreign market, Cost of goods sold, etc.).

The binary relationship '*includes*' models the link between the entity types FIN_STMT_LINE and FIN_CATEGORY. Each financial statement line includes only one financial category, but because financial categories may be generally measured/expressed in different units (attribute *fs_cat_unit*) and do have various values (attribute *fs_cat_value*) over time, the relationship '*includes*' has a cardinality of M:N and is mandatory on both sides.

5.2 Logical Design

Given the E-R diagram in Fig. 1 and the rules for mapping it into a corresponding logical design (Elmasri & Navathe, 2016, pp. 289−306), the resulting relational schema can be specified by the following set of relations:

COMPANY (comp_ID, comp_name, comp_address, comp_city, comp_state, comp_description, comp_URL, comp_established, comp_type, ISIN_code, activity_sector, activity_division, activity_group, activity_class, activity_subclass, comp_size)

FIN_STMT_TYPE (fs_type_ID, fs_type_name)

FIN_STATEMENT (fs_ID, fs_name, fs_date_issued, fs_fiscal_year, fs_fiscal_period, fs_start_date, fs_end_date, *comp_ID**, *fs_type_ID**)

FIN_CATEGORY (fs_cat_ID, fs_cat_name, fs_cat_description)

FIN_STMT_LINE (fs_ID*, fs_line_ID, fs_line_order, fs_line_title, fs_line_alias, fs_line_description)

INCLUDES (fs_ID*, fs_line_ID*, fs_cat_ID*, fs_cat_unit, fs_cat_value)

In the above relational schema, primary key (PK) attributes are bolded and underlined with a solid line; non-key attributes are written regularly;

foreign key (FK) attributes are italicized, underlined with a dashed line, and denoted by an asterisk (*); attributes that are simultaneously both primary and foreign keys are bolded, underlined with a solid line and also denoted by an asterisk (*).

The logical design, i.e. the set of relations that form the relational schema of the financial database, is independent of any particular relational DBMS.

It should be notified that in the relation FIN_STMT_LINE, the non-key attribute *fs_line_title* can take different values, depending on the type of financial statement.

For instance, Table 1 shows the possible values of this attribute commonly used in the Balance Sheet.

Table 1. Possible values of the non-key attribute *fs_line_title* used in the Balance Sheet

Values of the non-key attribute *fs_line_title* used in the Balance Sheet	
Non-current assets	Equity
Intangible assets	Subscribed capital and revaluation reserves
Property, plant, and equipment	Reserves
Other long-term assets	Retained earnings
Investment properties	Minority interest
Long-term financial instruments	Liabilities
Investments in subsidiaries	Current Liabilities
Investments in associates	Trade liabilities and other short-term liabilities
Long-term loans, receivables	Short term borrowings
Financial investments	Short term provisions
Other long-term receivables	Deferred tax liabilities
Current assets	Other current liabilities
Inventories	Accrued expenses
Trade receivables	Liabilities related to the disposal of assets
Other receivables	Long term liabilities
Short Term Financial investments	Long term borrowings
Cash and cash equivalents	Trade payables and other long-term liabilities
Prepaid Expenses	Long term provisions
Total Assets	Long-term tax liabilities
Equity and Liabilities	Total capital and reserves

Table 2 lists the possible values of the attribute *fs_line_title* commonly used in Income Statements.

Table 2. Possible values of the non-key attribute *fs_line_title* used in the Income Statement

Values of the non-key attribute *fs_line_title* used in the Income Statement	
Total operating revenues	Total financial revenues
Sales revenues	Financial revenues from investment, loans granted, and interest and exchange rate gains
Other operating revenues	Other financial revenue
Total operating expenses	Income from associated companies
Costs of trading goods sold	Total financial expenses
Cost of consumed materials and other supplies	Financial expenses from interest and exchange rate gains
Cost of materials, spare parts, and other inventory sold	Other financial expenses
Service cost	Losses from associates
Amortization and depreciation	Profit from ordinary activities
Impairment losses of non-current assets	Profit from ordinary activities before taxation
Impairment losses of current assets	Corporate tax
Provisions	Net profit
Other operating expenses	Net profit minority shareholders
Operating profit	Total other comprehensive income

Table 3 lists the possible values of the attribute *fs_line_title* commonly used in Cash Flow Statements.

As per the positions listed in these three tables, it is noteworthy to point out that they represent the most usually used ones. Some of them can be found with different names in other financial statements and it was the main reason to include the attribute *fs_line_alias* in the relation FIN_STMT_LINE.

Table 3. Possible values of the non-key attribute *fs_line_title* used in the Cash Flow Statement

Values of the non-key attribute *fs_line_title* used in the Cash Flow Statement	
Cash flows from operating activities	Capital gains/losses from the sale of investments

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Depreciation of properties, plants, and equipment	Other cash receipts and payments from operating activities
Gain/loss from impairment	Cash flow from investing activities
Increase/decrease in inventories	Cash payments from the acquired property, plant and equipment, intangibles, and other
Increase/decrease in receivables-customers	Cash flow from financing activities
Increase/decrease in advance payment	Cash proceeds from issuing shares or other equity instruments
Increase/decrease in short-term receivables	Cash repayments from amounts borrowed
Increase/decrease in paid expenses for future periods	Cash proceeds from issuing debentures, loans, notes, bonds, mortgages, and other short or long-term borrowings
Increase/decrease in payables	Cash payments to acquire a minor interest
Increase/decrease in received advanced payments	Dividends paid
Increase/decrease in short-term payables	Repurchase of own shares and stakes
Increase/decrease in deferred expenses	Cash payments by a lessee for the reduction of the outstanding liability relating to a finance lease
Interest paid/received	Net increase in cash and cash equivalents
Dividends paid/received	Cash and cash equivalents at beginning of the period
Tax expense	Cash and cash equivalents at end of the period
Capital gains/losses from the sale of property, plant, and equipment	

6. Conclusion

Designing and implementing a financial database can be an incredibly large and often expensive endeavor, especially due to the need for its continued maintenance and updating, as well as because of the need for engaging substantial hardware resources to keep it highly available and

scalable. On the other hand, the benefits of deploying such a database, like the significant increase in productivity and efficiency for all their users, will make the investments in time, human resources, and money worthwhile. Moreover, properly maintained and constantly updated financial databases can offer a myriad of useful historic data that, when properly processed and analyzed, can provide substantial insights. Financial databases are great sources of various types of data that can be helpful in financial modeling to forecast a particular business' financial performance in the future, typically based on the company's historical performance, assumptions about the future, and the three types of financial statements mentioned previously. The 3-way financial model is a setup for building all other financial models, such as Discounted Cash Flow (DCF) Model, Merger Model (M&A), Initial Public Offering (IPO) Model, Leveraged Buyout (LBO) Model, 'Sum of the Parts' Model, Consolidation Model, Budget Model, Forecasting Model, and Option Pricing Model, which are some of the most common types. The experiences concerning the use of such micro-databases have revealed many advantages *vis-à-vis* the production of various statistics and assessment of companies' financial structure development. The advantages of such an approach exceed largely the burden of successfully managing a vast amount of data, considering the benefits of refined quality control that allows for more reliable statistics and transparent data, higher compilation and exporting flexibility, and enhanced responsiveness to *ad hoc* user requests/queries. The coverage of such financial databases in terms of the different financial instruments with various levels of detailed information that can be searched by a company, country, and many other criteria allows for the compilation of valuable statistical outputs which are of key importance for the policymakers. If extended to a global scale, by sharing the data across international borders, the benefits could not just be spread out worldwide, but also multiplied.

The future work involves the physical design and implementation of the hereby presented logical design using a particular relational DBMS (e.g. Microsoft SQL Server, Microsoft Access, MySQL, etc.), being the third and the last phase of the process of designing a relational financial database.

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