

**Abstract.** The research explores a method for analyzing financial data through the usage of Behavioral Change Indicators (BCI). It presents the BCI-based method for identifying financial anomalies, alongside the design of a architecture for detecting these anomalies. Furthermore, it introduces a theoretical architectural approach for recognizing financial irregularities, which has been effectively implemented using the Camunda business rules engine and rigorously tested with real financial data. Key Performance Indicator (KPI) stated as a quantifiable measure of performance over time for a specific goal. KPIs provide objectives for teams and insights that help members across the organization make better decisions. Key Performance Indicators practically help every area of the business move forward at the strategic level. For managing the fiscal health of the organizations are required to know about the performance as well as about Behavioral Change Indicators (BCI). Financial data of the organization may be analyzed from different views for discovery of certain patterns and/or anomalies. In this research there is provided list of financial data set anomaly detection steps; there is described how to use Key Performance Indicators (KPI) in organization's finance management process. There is presented detailed example of financial data analysis using BCI. Provided BCI calculation and visualization example helps to define the benefits of BCI usage in financial data analysis. The presented results are part of deliverables of research project "Enterprise Financial Performance Data Analysis Tools Platform (AIFA)". The research project was funded by European Regional Development Fund according to the 2014–2020 Operational Programme for the European Union Funds' Investments under measure No. 01.2.1-LVPA-T-848 "Smart FDI". **Keywords:** Data Mining, Finance Analytics, Financial Anomalies, Key Performance indicators, Behavior Change Indicator.

**Introduction.** The performance management measurement metrics are used by most of the organizations to ensure that either they are going on the right path or not. Key Performance Indicator (KPI) stated as a quantifiable measure of performance over time for a specific target or objective. KPIs provide targets for teams and in-sights that help people across the organization make better decisions. From finance and Human Resources to marketing and sales, Key Performance Indicators help every area of the business move forward at the strategic level. KPIs are an important way to ensure that teams or working groups are supporting the overall goals of the organization. Here are some reasons why the company need Key Performance Indicators for example: to keep the teams aligned, provide a company's "health" check, make adjustments as well as hold the teams accountable. For managing the fiscal health of the enterprises are required to know about the performance as well as Behavioral Change Indicators (BCI).

Financial data of the company may be analyzed from different perspectives for discovery of certain patterns, anomalies and frauds. In this paper there is provided list of financial data set anomaly detection steps; there is described how to use Key Performance Indicators (KPI) in company's finance management process. There is presented detailed example of financial data analysis using Behavioral Change Indicators. Provided BCI calculation and visualization example helps to define the benefits of BCI usage in financial data analysis.

The structure of the article is as follows. Introduction, second section provides an analysis of related work that examines the use of KPIs and BCIs. Third section de-fines Behavioral Change Indicators aimed for financial data analysis and anomaly detection. There are particular examples of BCIs calculation and visualization provided. The fourth section describes the problems of setting KPIs and BCI thresholds. Fifth section presents financial data set anomaly detection steps and provides architecture of sub-system for anomaly detection. The sixth section and conclusions summarize the benefits of using BCI for financial data analysis.

**Financial Data Analysis Using Behavioral Change Indicators.** Key Performance Indicators (KPIs) are commonly used for business enterprise performance analysis. Financial Key Performance Indicators used to measure a company's performance - a real world process. Financial KPI were divided by the seven categories of indicators: profit measures, cash flow measures, profitability ratios, liquidity ratios, solvency ratios, efficiency ratios and capital market ratios.

We suggest analyzing the company's financial data, and especially the financial KPIs, using other type of indicators. We suggest the use of Behavior Change Indicators (BCI) for the analysis of financial accounting data, i.e. analysis and evaluation of the behavior of financial KPIs.

The Behavioral Change Indicators (BCIs) are already being applied in other areas of activity and science, as described below.

Similarities and differences between Key Performance Indicators (KPI) and Behavioral Change Indicators (BCI) in brief:

- ❖ Financial Key Performance Indicators (KPIs) are used as a basis to analyze performance of enterprise (business process) using financial accounting raw data.
- ❖ Behavioral Change Indicators (BCI) are useful for analysis of financial accounting indicators, evaluation of financial KPIs data time series and are aimed for anomaly detection.

We suggest using the capabilities of BCIs to analyze financial data, to look for anomalous behavior of financial data, especially to examine changes in KPIs over time.

**Financial data Behavioral Change Indicators (BCI).** Another group of indicators next to KPI used as a basis for process analysis (behavior analysis) in various areas of reality (domains) is called Behavioral Change Indicators (BCI).

Behavioral Change Indicators (BCI) are used for process research in various areas: economics (behavioral economics), psychology and sociology fields (human behavior understanding), in environmental sciences, in climate change monitoring, evaluation and adaptation, public policy analysis and other domains of reality.

The difference between a KPI and a BCI can be explained as follows: KPIs are used to measure and evaluate outcomes of business processes, and BCIs are used to detect changes in the KPI values over time, evaluate changes, and achieve the target (normative) behavior you want to see. BCIs can be used in a variety of activities and disciplines, in addition to KPIs, if required.

We implemented few types of BCIs in enterprise finance management domain for the analysis and evaluation of changes in the financial indicators of enterprises over time (Table 1).

Some BCIs not included in Table 1 are also used in practice:

- ❖ BCI-R (t, t\*) - change in KPI Rating in financial period t compared to the same KPI rating in financial Period t\*;
- ❖ BCI-AR - unusual or rare KPI value occurrence (global anomaly) in some period (t, t\*);
- ❖ BCI-ARC - unusual or rare co-occurrence of two KPI values (local anomaly) in some period (t, t\*).

Table 1. Financial data Behavioral Change Indicators (BCI)

Behavioral Change Indicators (BCI)	Notation	Description
1. BCI-A: Absolute change in KPI over given financial period		BCI-A is the difference in KPI value over some financial accounting period, i.e. financial year, month, etc.
1.1 BCI-A1: Absolute change in KPI in the financial period t	$\Delta X(t, t')$	BCI-A1 is the difference between the value of KPI in period t and given previous period t'.
1.2 BCI-A2: Absolute change in KPI in the financial period t compared to the moving average of the KPIs over the financial periods (t', t'')	$\Delta XA(t, (t', t''))$	BCI-A2 is the difference between the KPI value in period t and the moving average of the KPI over the periods (t', t'')
2. BCI-RO: Robustness coefficient, an indicator of stability	$\Delta XRO(t, XN)$	BCI-RO is the difference between the KPI value in period t and the normative (reference) value XN.
3. Relative Behavioral change indicator BCI-RE		
3.1 BCI-RE1: Relative change in KPI in the financial period t (the ratio to the previous period t')	$\Delta XRE(t, t')$	BCI-RE1 is the ratio of the change in the KPI to the previous period's KPI value (in percentage terms)
3.2 BCI-RE2: Relative change in KPI in financial period t (the ratio to the average value over previous periods (t', t''))	$\Delta XREA(t, (t', t''))$	BCI-RE2 is the ratio of the change in the KPI to the previous periods (t', t'') KPIs average value (in percentage terms)
4. Delta BCI (D-BCI) shows change in absolute or relative BCI compared to certain defined period.		Definition: Delta BCI means the change in BCI compared to certain defined period.
4.1 D-BCI-A shows an absolute change in BCI XA(t, t*) in financial period t compared to change in BCI-A in previous period t'	$D(\Delta XA(t, t'))$	A set of D-BCI-A shows a trend of change in BCI-A over a period of time (over a set of periods)
4.2 D-BCI-RE is the ratio of the change in BCI-RE in period t compared to change in BCI-RE in previous period t'		A set of D-BCI-RE shows a trend of change in BCI-RE over given period (in percentage terms)
4.3 D-BCI-RO shows the change of the Robustness Coefficient BCI-RO in some period (t, t*) (trend of BCI-RO change)		A set of D-BCI-RO shows a trend of change in BCI-RO over a period of time (over a set of periods)

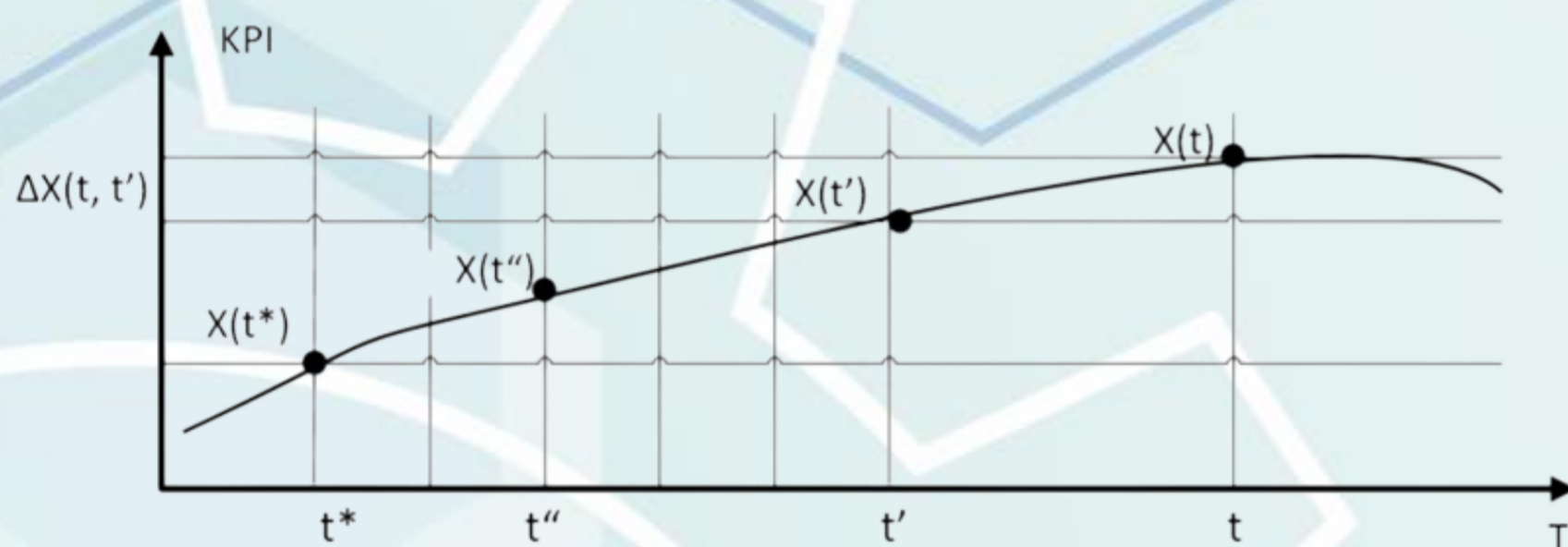


Figure 1. Abstract KPI time series

In financial accounting the accounting period is determined by management regulation and is usually 12 months. Monthly accounting periods are common in management accounting. In the ERP tools there are more than 12 accounting periods in a financial year. So, accounting period is determined by management and varies widely. Financial accounting period t is an attribute (time stamp) in the data base of ERP tool and is interpreted as time point.

In short, the financial accounting period t will hereinafter be referred to as the "financial period t" and means a time point on the time axis T (Fig. 1), where X(t) is a value of KPI.

We define three types of indicators of changes in the behavior of financial data (BCI):

- ❖ absolute change indicators (BCI-A);
- ❖ relative change indicators (ratio indicators BCI-RE);
- ❖ delta change indicators (D-BCI).

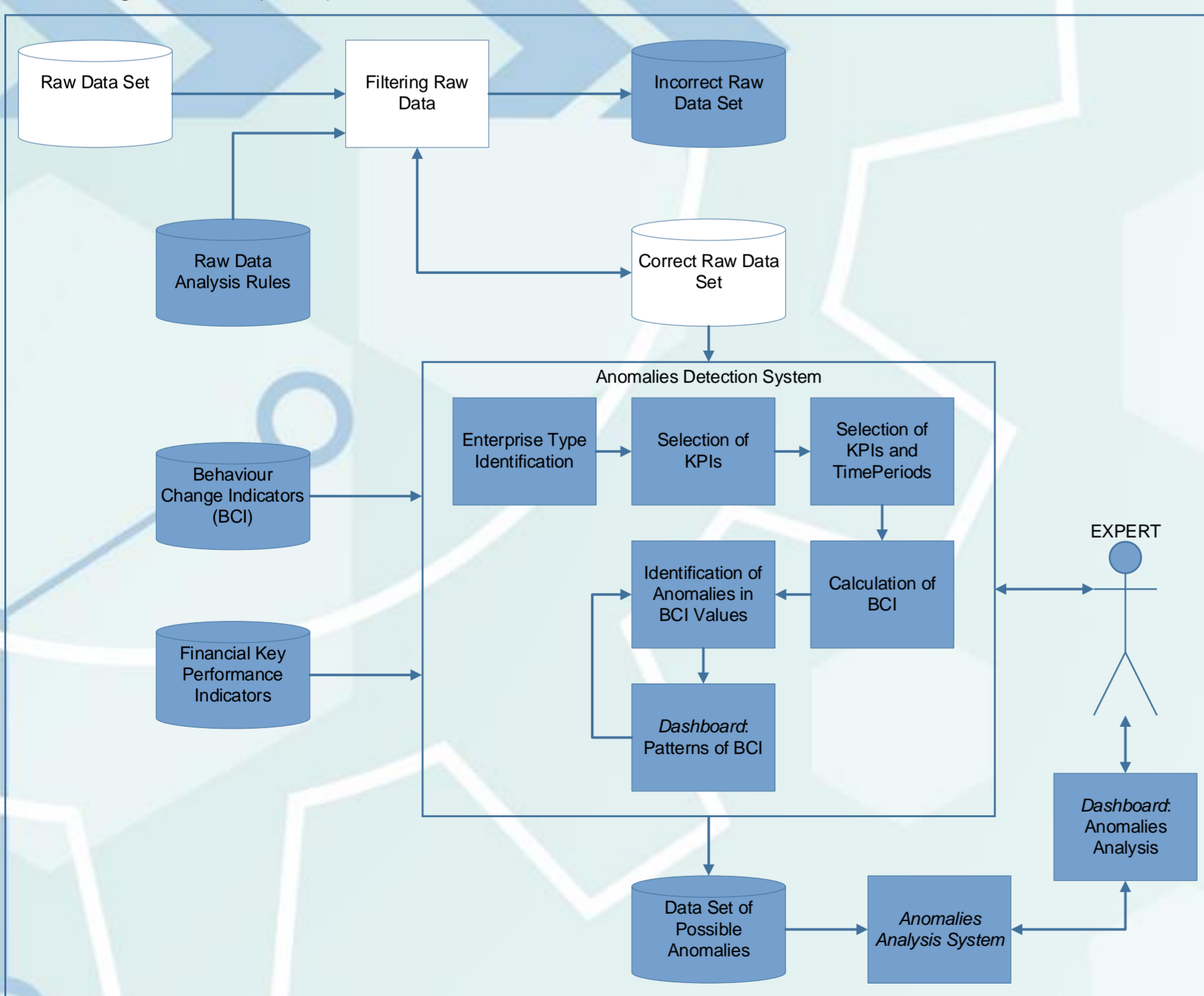


Figure 2. Architecture of sub-system for anomaly detection

**Thresholds of KPIs and BCIs.** A change in the value of a KPI, if it exceeds a certain threshold (considered sudden, unusual, anomaly, suspicious), is one of the most important signs of a change in a company's decisions or business processes, human resources, or accounting policies. Therefore, the Behavior Change Indicators (BCIs) presented in Table 2 are useful for detecting financial KPI anomalies over different time periods.

Table 2. Financial KPIs thresholds

Financial KPI	Formula	Normative threshold
Current ratio (Cr)	Cr = Current assets / Current liabilities	Cr > 1.0 (1.2)
Acid test (Quick) ratio (Ar)	Ar = Current assets - inventory / Current liabilities	Ar > 1.0
(Cash ratio) (CA)	CA = Cash / Current liabilities	0.1 < CA < 0.2
Working capital to total assets (NWC)	NWC = Working capital / Total assets	1.5 < NWC < 2
Debt ratio (Dr)	Dr = Debt / Total assets	0.5 < Dr < 0.7
Debt to equity ratio (De)	De = Debt / Equity	De < 2.0
Bankruptcy Indicator Altman Z SCORE (Z)	$Z = 0.717(X1) + 0.847(X2) + 3.107(X3) + 0.420(X4) + 0.998(X5)$ (1) where X1 = Working capital/Total assets, X2 = Retained earnings/Total assets, X3 = Earnings before interest and taxes/Total assets, X4 = Book value of Equity/Book value of total liabilities, X5 = Net sales/Total assets	[0 - 1.8] - Distress zone; [1.8 - 3.0] - Grey zone; [3.0 - 4.0] - Safe zone.

**Financial Data Set Anomaly Detection.** The main financial anomaly detection steps are listed below:

- ❖ Discovery of a normalized model (company-specific)
  - ❖ to detect anomalous journal entries, we first have to define "normality" with respect to accounting attribute type, indicator type.
- ❖ Identification of deviations of attribute values
  - ❖ exhibit unusual or rare individual attribute values. Such anomalies usually relate to skewed attributes, e.g. rarely used ledgers, journals or unusual posting times. Traditionally, "red-flag" tests performed by auditors during an annual audit, are designed to capture this type of anomaly.
- ❖ Unusual or rare combinations of attribute values:
  - ❖ journal entries that exhibit an unusual or rare combination of attribute values while their individual attribute values occur quite frequently:
    - ❖ e.g. unusual accounting records,
    - ❖ irregular combinations of general ledger accounts,
    - ❖ user accounts used by several accounting departments.
- ❖ Actual time periods list.

**Advantages of using BCIs in Financial Data Analysis.** Unexpected changes in the behavior of some KPIs are one of the most important indicators related to changes in corporate decisions or business processes, human resources or accounting policies. The main advantages observed in the use of behavioral change indicators are:

- ❖ The BCI-A shows the change in the value of a particular KPI over a period of time (t) compared to the value of that KPI in another time period, such as the previous time period (t-1), or the average, or normative value of a KPI.
- ❖ BCI-RE shows a relative change in KPI in the financial period t - the ratio to the previous period t' or to the average value over previous periods (t', t'');
- ❖ Delta BCI (D-BCI) shows change in absolute or relative BCI compared to certain de-fined period.

Such quantitative and visualized information on KPI behavior over time from BCI calculations highlights what it is almost impossible for a person to comprehend with KPI data alone.

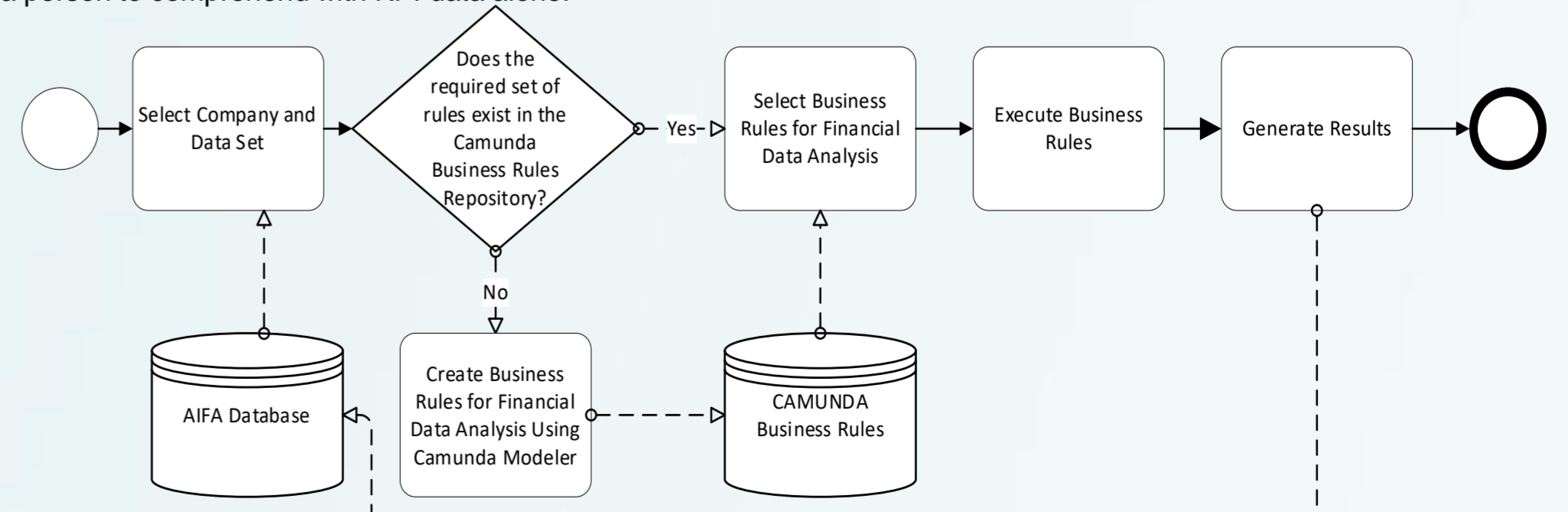


Figure 3. The main steps of financial data analysis process

**Conclusions.** The article presents the approach to detecting anomalies in financial data, using indicators of behavioral change (BCIs) next to traditional KPIs. This is as one of the results of the project "Platform of tools for the analysis of corporate financial activity data".

Three types of indicators of changes in the behavior of financial data (BCI) are de-fined absolute change indicators (BCI-A), relative change indicators (ratio indicators BCI-RE) and delta change indicators (D-BCI).

There advantages to using BCI in financial data analysis can be summarized as follows: BCI calculations highlights quantitative and visualized information on KPI behavior over time. A change in the value of a KPI, if it exceeds a certain threshold, is one of the most important signs of a change in a company's decisions or business processes or human error.

It is almost impossible for an expert alone to comprehend by analyzing the abundant financial KPI data. Using BCI to track changes in KPIs and detect suspicious trends in KPI changes (indicating anomalies in financial data) reduces the amount of data that needs to be analyzed. However, determining acceptable limits (thresholds, normative values) for financial BCI (for specific KPIs) is a complex issue, a matter of using expert knowledge.

The architecture version of the financial data anomaly detection subsystem present-ed. The expert knowledge (business rules), these are KPI and BCI models with a range of normative values (thresholds) are content of financial knowledge base. Business rules are created in Camunda Modeler platform using decision tables.

By setting BCI thresholds in a system prototype environment, templates can be created to detect financial data anomalies, automatically forming sub-sets of suspicious data. The software system would automatically assess the meanings and risks of changes in KPIs and detect suspicious trends in KPI changes and indicate this on the dashboard.