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Maschine Learning Solutions for the CFO Office

- Cash Prediction & Forecasting -

10.01.2020

Challenges for Cash Position Forecasting

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Reasons

Cash-in is dependent on **customer behavior** at payment processes.

Cash-out might vary depending on **unplanned changes** in delivery dates, fulfillment dates or resource bottlenecks.

Challenges

High manual effort for the generation of cash forecasts

Low quality of key figures in the forecasting process

Different forecast values between Treasury and Controlling

Self-defeating decentralized measures for cash handling

No use of transactional data for the Management Decision

Mission of Cash Forecasts with Advanced Analytics

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Mission is to **automate, improve and enhance** the short- and mid-term cash forecast based on open invoices or other cash relevant transactions

1. to lift the **accuracy of cash forecasts** on daily and monthly level
2. to guarantee liquidity and to **focus on the improvement** of the cash position
3. to **gain insights** on value drivers for the time span until cash in

Invoice & Cash Data are combined to enable Cash Predictions

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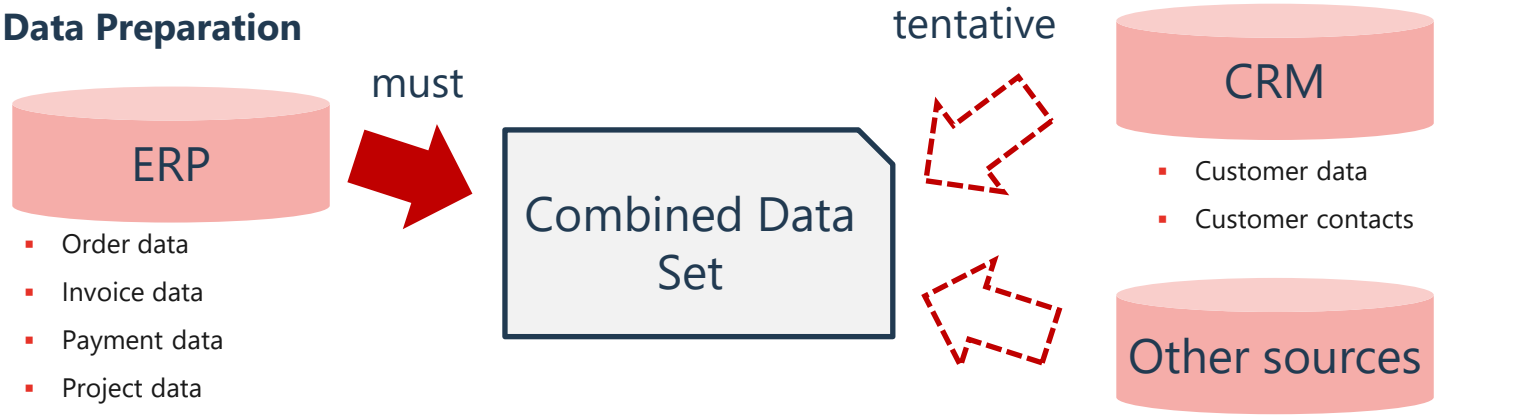
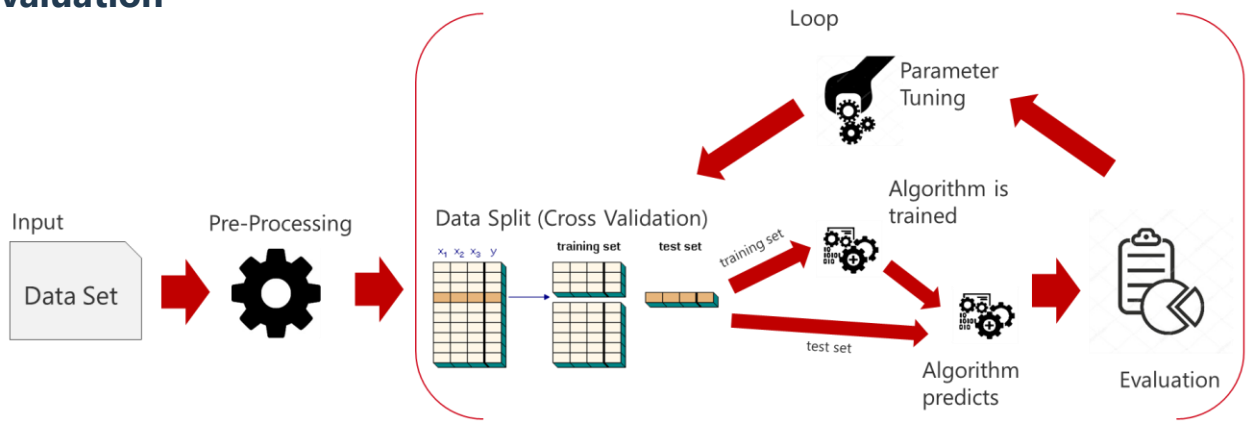
Data Preparation



Standard data can be generated out of transactional systems, e.g. SAP ERP

Modeling & Evaluation



Afterwards the modeling phase starts with the goal to find the best model in order to make cash in forecasts on daily and monthly level

Random Forest Algorithm predicts Cash In Dates for each open Invoice

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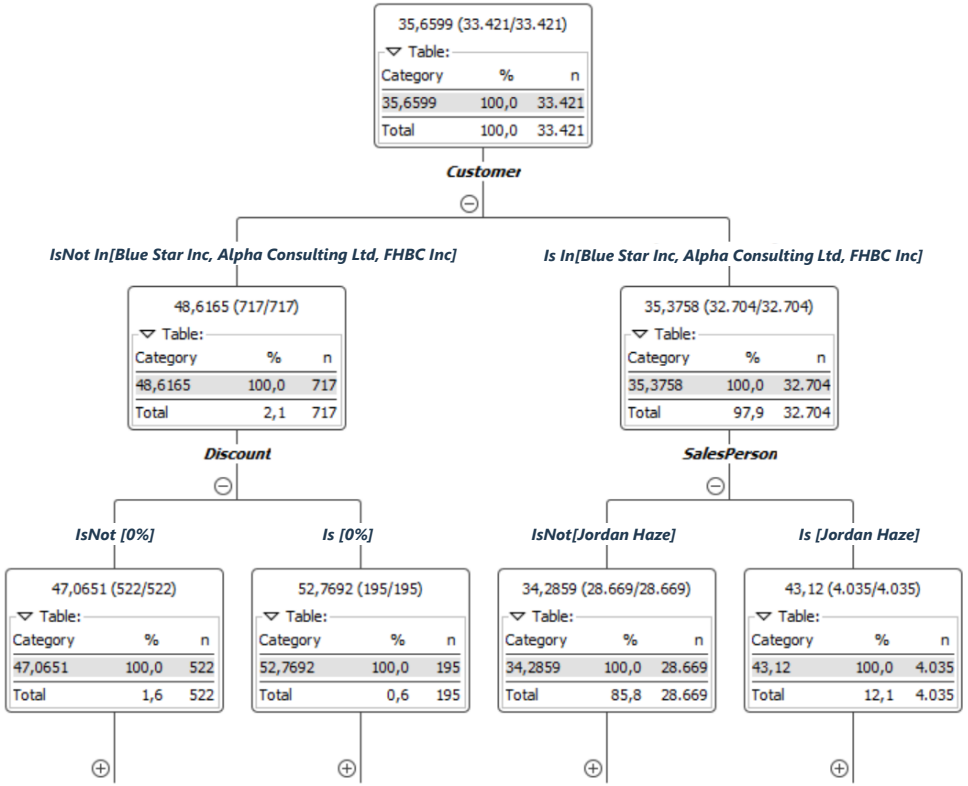
Decision Tree (reduced representation)



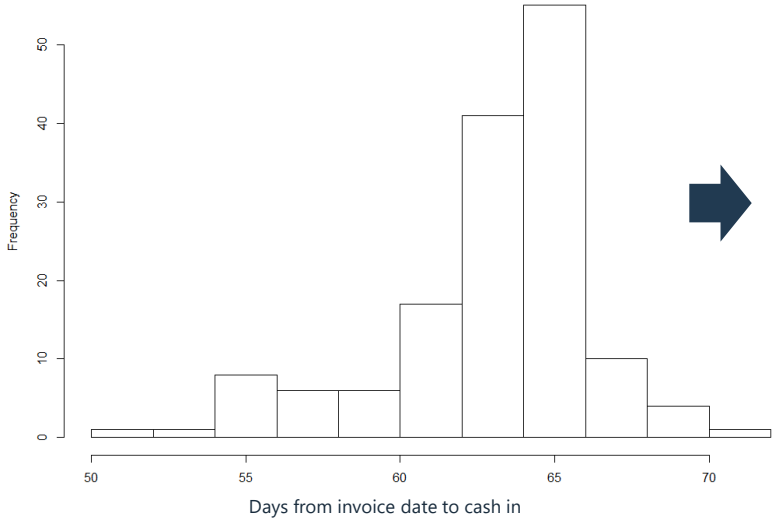
Random Forest algorithm learns from the past and predicts open invoices

Patterns from past invoices, payments, customer & order information are found by decision tree algorithms

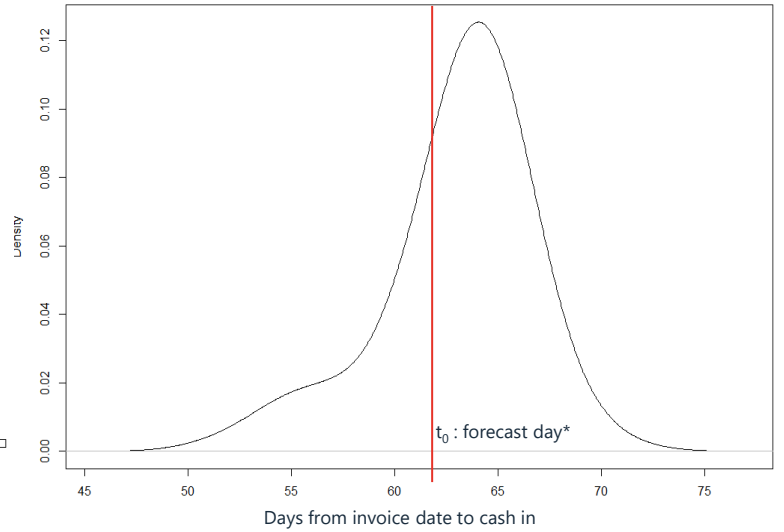
- Invoices are split into several different buckets by various extracted variables (categories) in the (training) data set resulting in a tree like representation
- The algorithm automatically chooses the best variable for the split and the splitting point at each level based on statistical criteria
- At the end of each branch the mean value for the time span between invoice date and cash in date is calculated for the remaining invoices at the branch leaf
- Each new invoice is associated to exactly one branch of the tree and therefore to the calculated value at the corresponding branch leaf
- Many different (usually > 100) trees are grown and combined to a random forest algorithm
- Each tree in the random forest predicts a value for the time span between invoice date and cash in date for each open invoice
- For data that follows explicit patterns the individual tree predictions fall into a small range, for invoices with ambiguous data the prediction variance is greater
- For each new forecast the algorithm is trained again to incorporate pattern changes over time

A Probability Density Function is built to predict Cash In on Daily Level

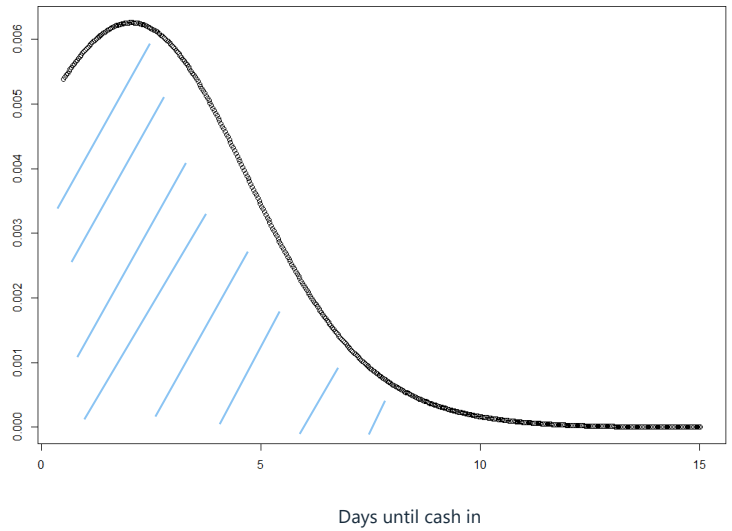
Probability distribution of a single invoice for the time span between invoice date and cash in date based on tree votes



Probability density function of a single invoice for the time span between invoice date and cash in date



Probability density function of a single invoice for the time span between forecast date* and cash in date



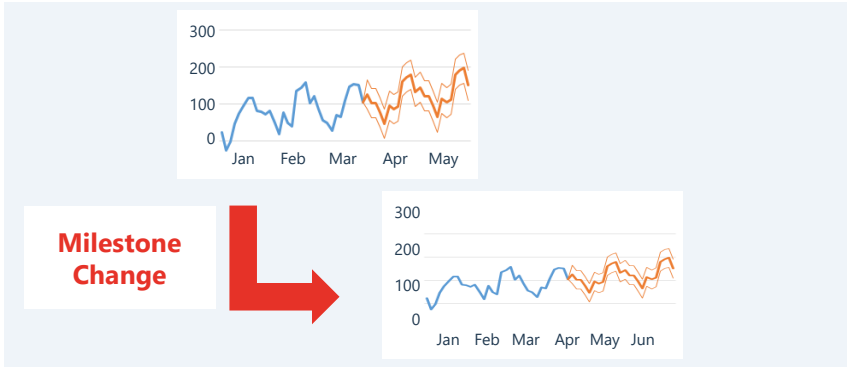
For each invoice an individual probability density function for the next days is built in order to predict the cash in

- Based on the individual tree votes for a single invoice a probability distribution is estimated for the time span between invoice date and possible cash in dates
- With the help of a kernel density estimator the discrete probability values can be converged into a continuous probability density function that allows to estimate the probability for each single day
- For open invoices sent some days before the forecast date* the part of the density function that is not valid anymore is cut and the area under the curve is normalized to one in order to predict the probabilities for each day between forecast date and possible cash in dates
- With the estimated probabilities per day the invoice amount can be distributed respectively and the distributed amounts of all open invoices are summed up for each day

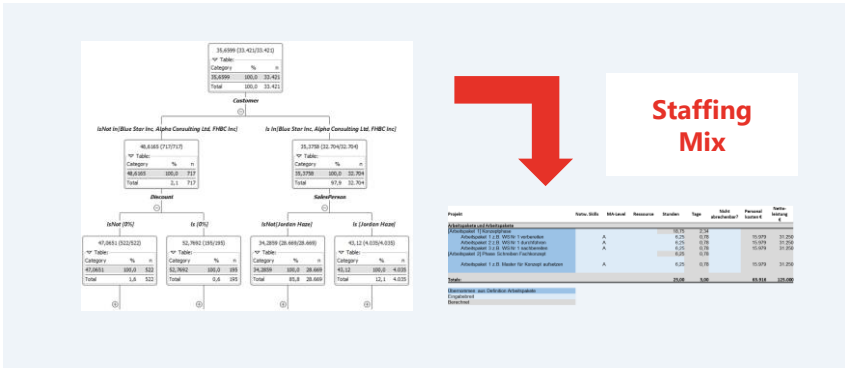
* day when the forecast is created

For Example Project Information triggers Cash Out

Time Series Model for Project Structures



Machine Learning Model



Deterministic model

Use historical information for detailed reporting purposes on project line item basis.

Changes can be aggregated through using an appropriate reporting tool and gathering all relevant information out of SAP ERP.

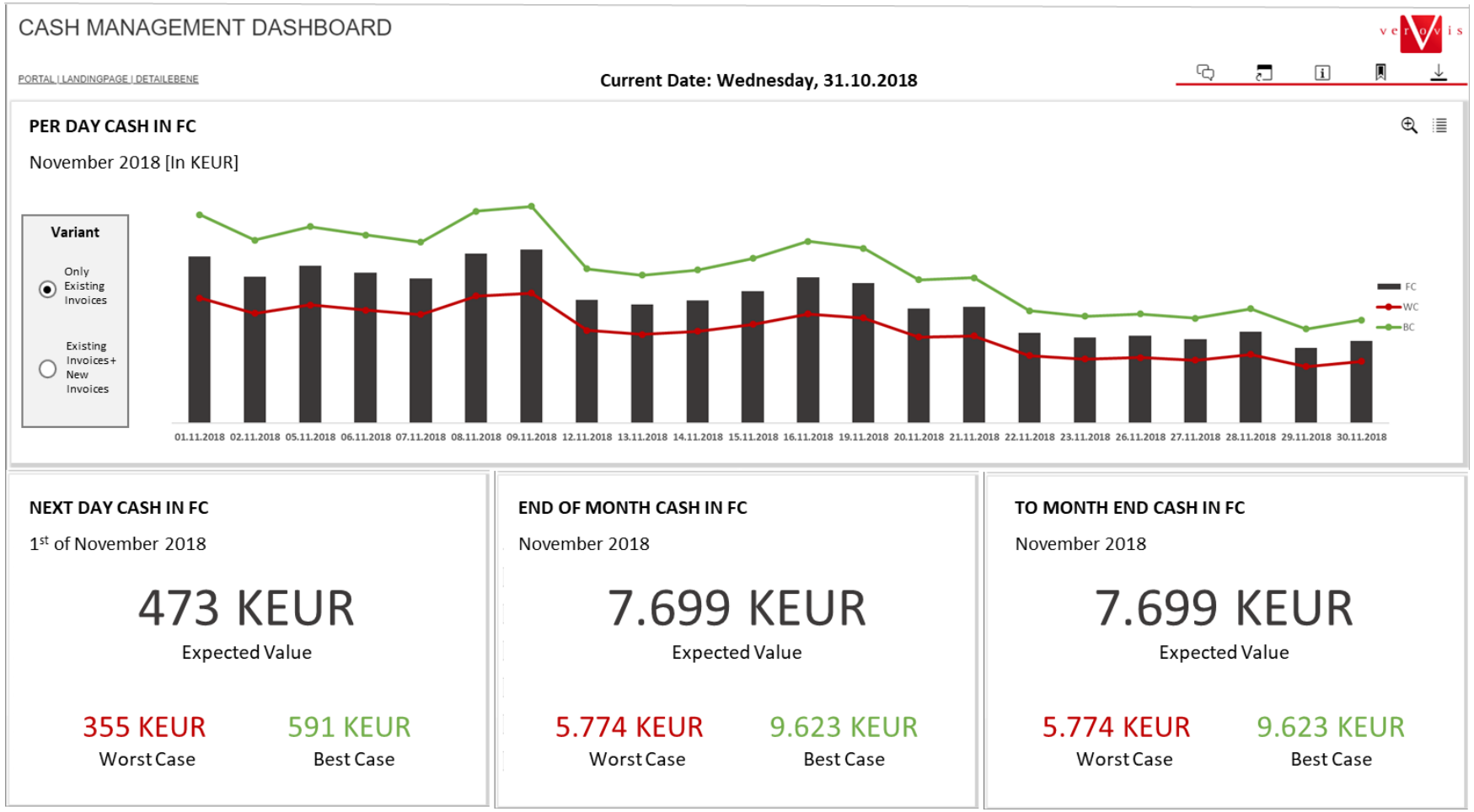
Time series projections provide long-term views

Machine Learning model

Line item information can be used to provide patterns per each project setup, which leads to optimization actions (e.g. staffing mix for services).

Prediction of invoice rhythm per vendor provides a prediction of cash out amount.

Predictions on Daily & Monthly Level are visualized in a Dashboard

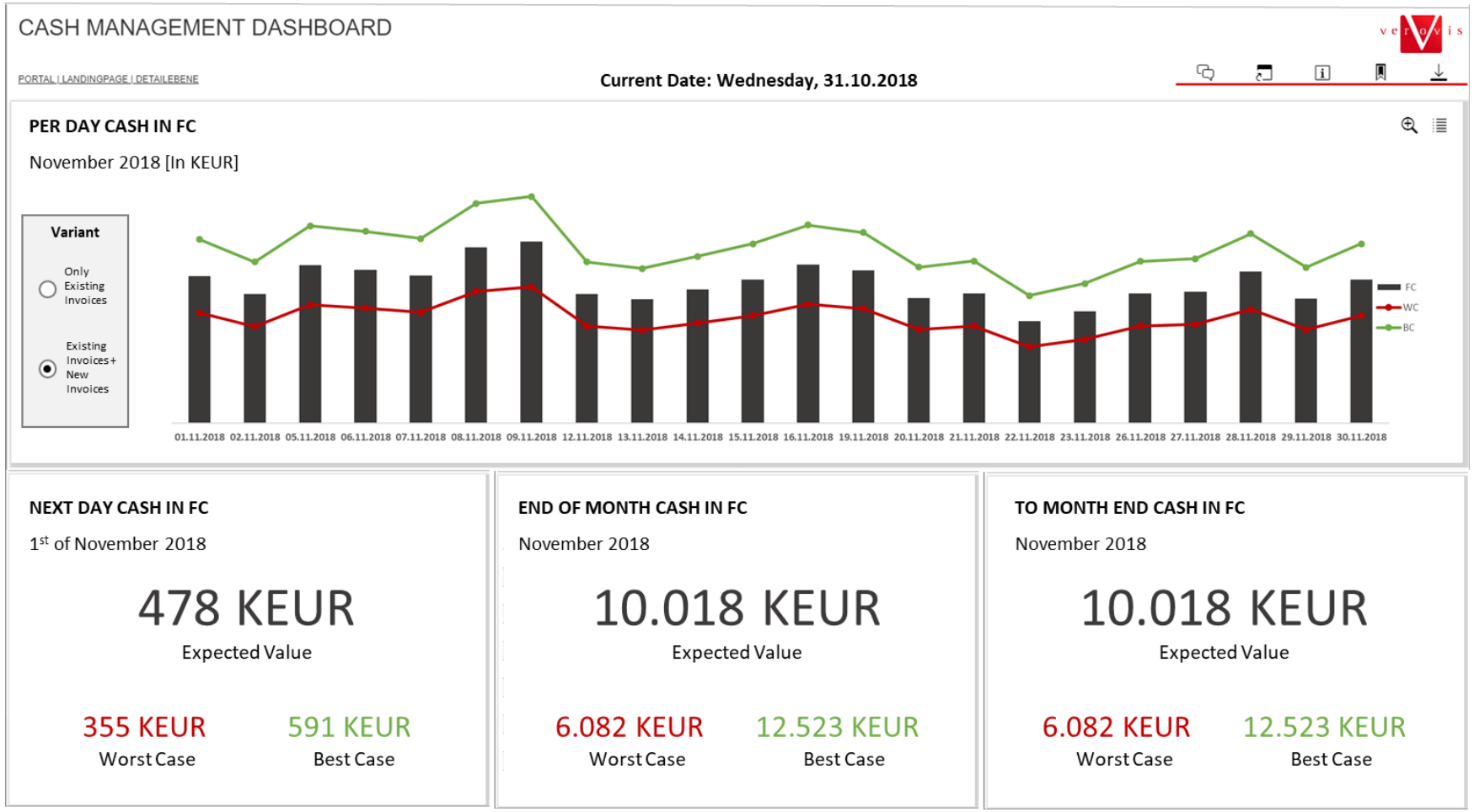


The cash in forecasts per day are visualized in a **Cash Management Dashboard** for a given time period (e.g. the next 30 days).
In order to **assess the risk of illiquidity worst and best case scenarios** can be estimated and visualized as well.

Two variants are possible:

- Prediction solely based on open invoices that are **already existing** on the forecast day
- Prediction based on open invoices that are already existing on the forecast day **plus a time series forecast** of invoices that are expected to be created and paid within the next days

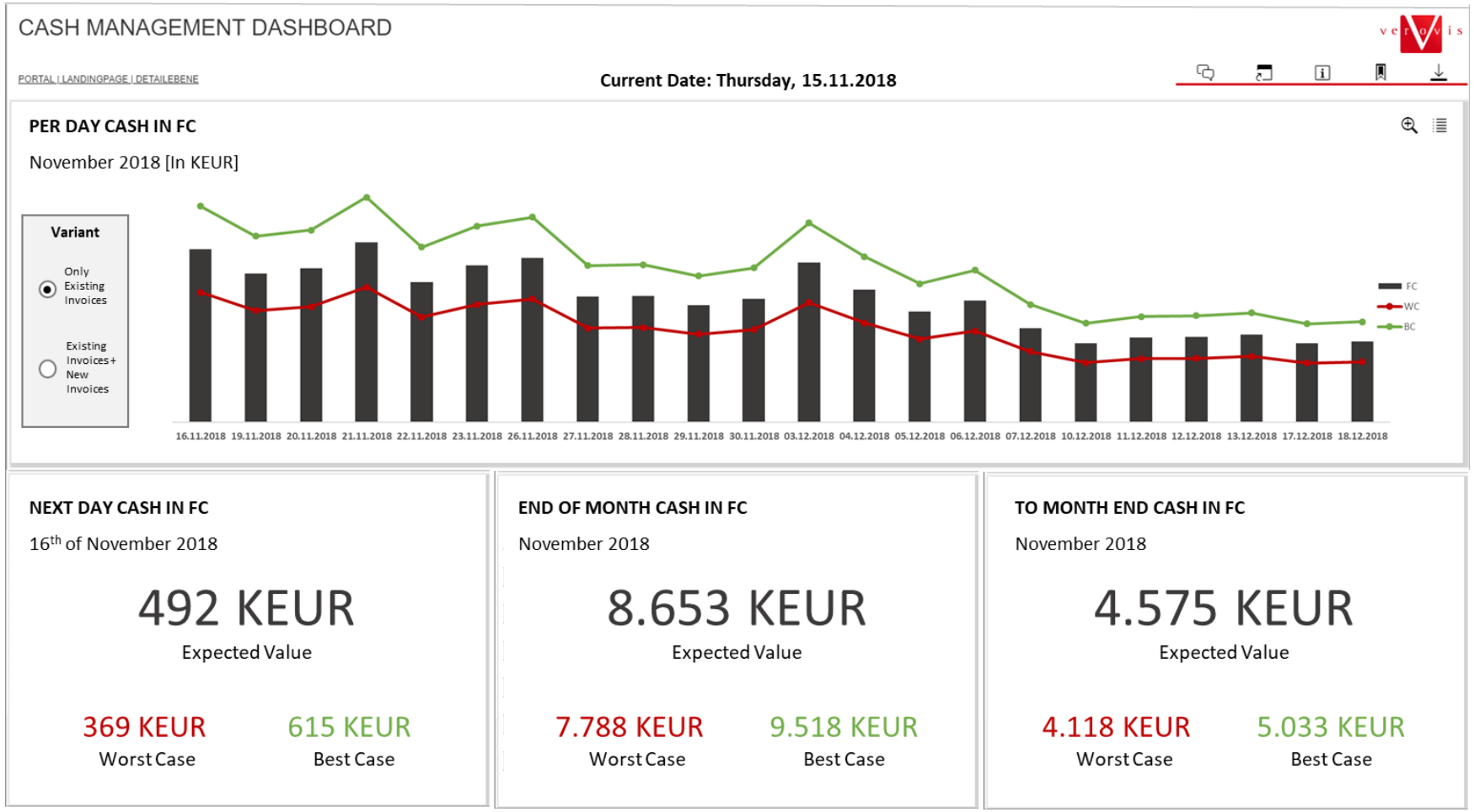
To incorporate new Invoices a Time Series Component is added



The first variant has a focus on the **very short-term cash in situation** and indicates the cash in **development if no new invoices were generated.**

The second variant **additionally forecasts** a cash in amount per day **from new invoices** being created and paid within the next days after the forecast day.
It **combines** the **machine learning** approach based on existing invoices with a **time series forecast** for payments deriving from new invoices.

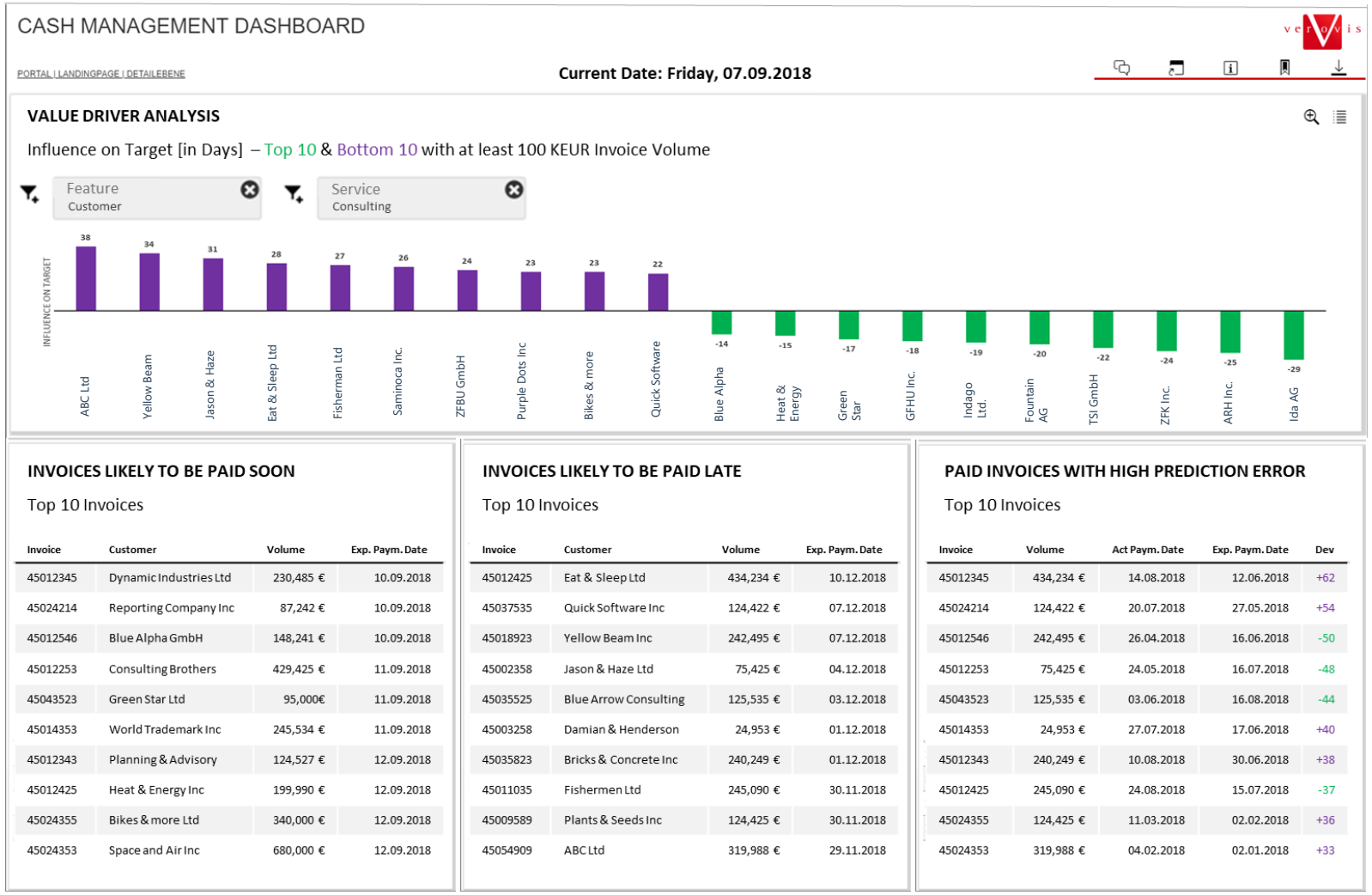
An automated Prediction at Night allows an updated FC every Day



The **prediction runs automatically during the night** in order to show updated **forecasts every day.**

With the time span getting smaller towards the month end **new invoices** are incorporated into the machine learning prediction and the **expected value will converge towards the month end actual value.**

Insights are generated with regard to Value Drivers



CASH MANAGEMENT DASHBOARD

PORTAL | LANDINGPAGE | DETAILEBENE

Current Date: Friday, 07.09.2018

VALUE DRIVER ANALYSIS

Influence on Target [in Days] – Top 10 & Bottom 10 with at least 100 KEUR Invoice Volume

Feature: Customer

Service: Consulting

INVOICES LIKELY TO BE PAID SOON

Top 10 Invoices

Invoice	Customer	Volume	Exp. Paym. Date
45012345	Dynamic Industries Ltd	230,485 €	10.09.2018
45024214	Reporting Company Inc	87,242 €	10.09.2018
45012546	Blue Alpha GmbH	148,241 €	10.09.2018
45012253	Consulting Brothers	429,425 €	11.09.2018
45043523	Green Star Ltd	95,000€	11.09.2018
45014353	World Trademark Inc	245,534 €	11.09.2018
45012343	Planning & Advisory	124,527 €	12.09.2018
45012425	Heat & Energy Inc	199,990 €	12.09.2018
45024355	Bikes & more Ltd	340,000 €	12.09.2018
45024353	Space and Air Inc	680,000 €	12.09.2018

INVOICES LIKELY TO BE PAID LATE

Top 10 Invoices

Invoice	Customer	Volume	Exp. Paym. Date
45012425	Eat & Sleep Ltd	434,234 €	10.12.2018
45037535	Quick Software Inc	124,422 €	07.12.2018
45018923	Yellow Beam Inc	242,495 €	07.12.2018
45002358	Jason & Haze Ltd	75,425 €	04.12.2018
45035525	Blue Arrow Consulting	125,535 €	03.12.2018
45003258	Damian & Henderson	24,953 €	01.12.2018
45035823	Bricks & Concrete Inc	240,249 €	01.12.2018
45011035	Fishermen Ltd	245,090 €	30.11.2018
45009589	Plants & Seeds Inc	124,425 €	30.11.2018
45054909	ABC Ltd	319,988 €	29.11.2018

PAID INVOICES WITH HIGH PREDICTION ERROR

Top 10 Invoices

Invoice	Volume	Act Paym. Date	Exp. Paym. Date	Dev
45012345	434,234 €	14.08.2018	12.06.2018	+62
45024214	124,422 €	20.07.2018	27.05.2018	+54
45012546	242,495 €	26.04.2018	16.06.2018	-50
45012253	75,425 €	24.05.2018	16.07.2018	-48
45043523	125,535 €	03.06.2018	16.08.2018	-44
45014353	24,953 €	27.07.2018	17.06.2018	+40
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Value Driver Analysis helps to identify the **influence of variables** in the data on the target value (time span until cash in).

This graph shows the **influence on the customer level** towards the time span in which the invoices are paid (in comparison to the overall mean). Only the top (lower timespan) and bottom customers (higher timespan) are displayed.

Filters allow to **select different features (variables) or segments / divisions** for the analysis.

Based on the predictions lists can be displayed with **invoices that are likely to be paid within the next days** or that are **likely to be paid with significant delay**. Customers with invoices that are predicted to be paid late can be **contacted with higher priority.**

The analysis of invoices with high prediction error indicates **pattern changes** since the real time span deviates strongly from the prediction based on identified past patterns and behaviors.

Insights are generated with regard to Value Drivers

CASH MANAGEMENT DASHBOARD

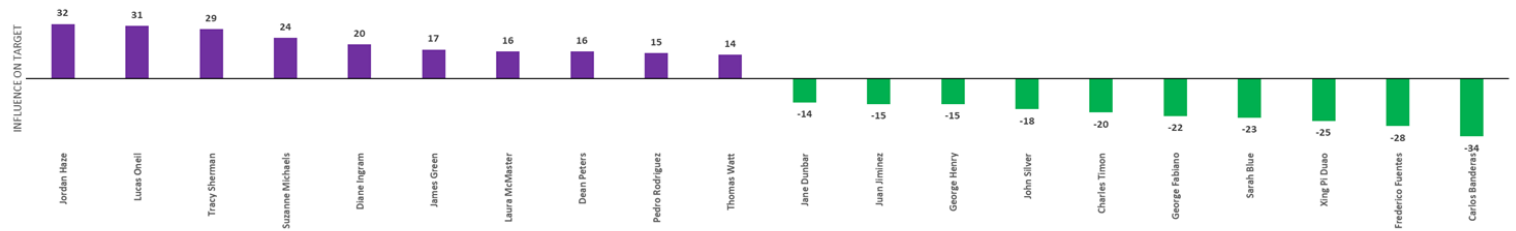
PORTAL | LANDINGPAGE | DETAILEBENE

Current Date: Friday, 07.09.2018

VALUE DRIVER ANALYSIS

Influence on Target [in Days] – Top 10 & Bottom 10 with at least 100 KEUR Invoice Volume

Feature: Sales Person | Service: All



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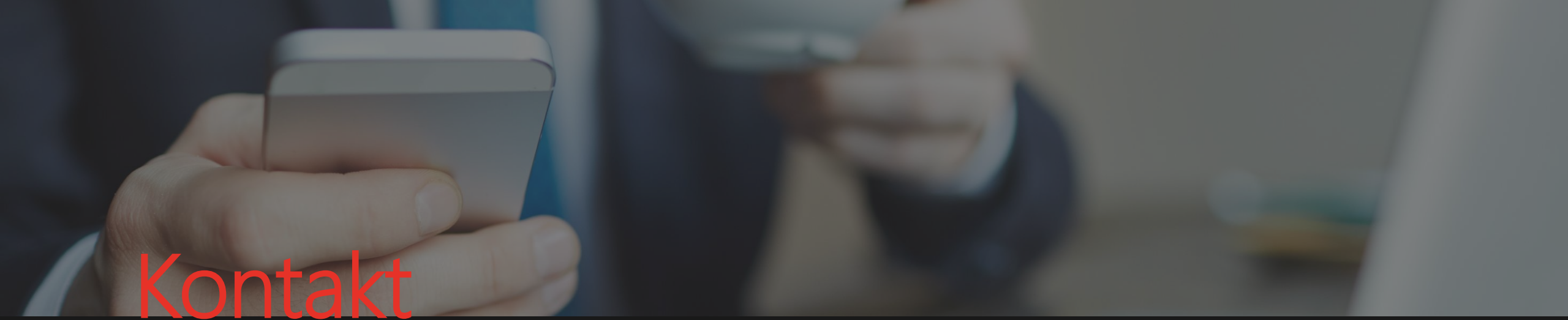
While the previous graph showed the influence of different customers this graph indicates the **influence of sales persons (account managers / partners)**.

This allows to **identify potential of improvement** with regard to the cash in time span.



Kontakt

Clemens Frank

Managing Director

cfrank@verovis.de
+49 (0)151 4023 4146

verovis GmbH
Erkrather Strasse 401
40231 Düsseldorf
Germany

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Machine Learning Use Cases for the Office of the CFO!

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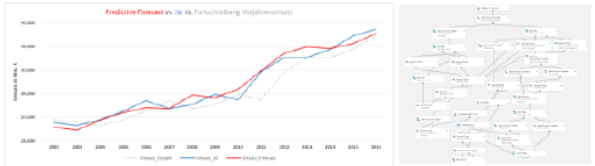
Cash Prediction

Benefits: Automated cash-in prediction and cash value driver analytics.
Data Sources: Accounts receivables and sales on document level as well as plan data on aggregated level.

Revenue Prediction

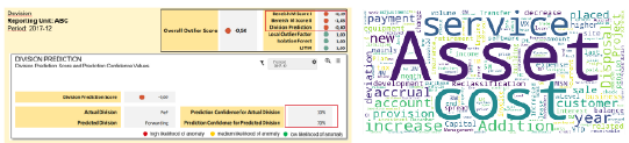


Benefits: Automated revenue prediction for plan data validation.
Data Sources: Sales information on document level as well as external indices and internal plan data accuracy.

EBIT Prediction

Benefits: Automated EBIT prediction for plan data validation.
Data Sources: Group/entity reporting on group/entity account level as well as notes information.

Group Reporting Anomaly Detection



Benefits: Rapid detection of false values as well as controlling console for data quality, including commentary information.
Data Sources: Group reporting on group account level.

Purchase-to-Pay Anomaly Detection

Benefits: Spend volume accuracy and automated category assignment.
Data Sources: Accounts payables as well as general accounting and procurement information on document level.

Tax Analytics

Benefits: VAT monitoring and fast identification of tax reduction opportunities.
Data Sources: Accounts receivables, accounts payables and general accounting information on document data.