“How Big Data is Changing Controlling”

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Dr. Michael Kieninger
Partner
CEO of Horváth AG
Speaker of the Managing Board
MKieninger@horvath-partners.com

Walid Mehanna
Former Principal and
Head of Business Segment
Business Intelligence & Big Data
at Horváth & Partners

Alexander Vocelka
Partner
Head of Competence Center Controlling &
Finance / Accounting, Treasury & Risk
Management
Head of the Steering Lab
AVoelka@horvath-partners.com

www.horvath-partners.com
Digitization and Big Data have a major impact on Controlling. The primary driving force is the utilization of Big Data through mathematical-statistical models. Already today these models are the basis for new management decision-making processes and optimization methods and current developments indicate that future operating models will look very different from today. The resulting changes lead to the target picture of a fully digitized and machine-driven performance management.

1. Digital Potential for Change

Data and the information derived from it are the foundation of controlling, making efficient and effective corporate performance management possible and providing support for all forms of decision-making. Thus, it is hardly surprising that the current wave of digitization, and Big Data in particular, will have a considerable influence on the controlling of the future. The changes triggered by Big Data will have such a huge impact on methods, instruments, skills and organizations that they will radically redefine the entire world of controlling. As information is the 4th production factor, Big Data has hugely boosted its importance and many experts see it becoming the most important of all production factors. This development has controllers questioning their own role, too. With machines making the most complex decisions in less time than the blink of an eye, how could controllers possibly add value that would justify their expense?

They saw it happen in accounting where digitization and automation will further cut the professional share by half within the next years. Controllers will have to adapt rapidly and change their profile in order to create value in new ways.

So, if machines are going to have all the answers - who will have all the questions. Over the next decade, it will be controllers who will have to ask the right questions for the machines to answer.

This will require multidisciplinary and systemic competencies. Machines see the world as complex interdependent systems. Humans still perceive the world as something deterministic, a composition of distinctive objects and sequential functions, which the world never was - but this simplified view was good enough in the past.

The future will require a systemic view and controllers will quickly have to adopt this capability in order to create the extra value in symbiosis with machines.

It would be presumptuous to believe that we can draw a detailed picture of tomorrow’s finance function today. However, certain fundamental changes are already clearly recognizable. We would like to show how Big Data fundamentally changes the very nature of the supply of information and how the interaction between new technological possibilities, methods and skills leads to a new type of performance management. From this, we will derive a target picture of the controlling function of the future.

1.1 Digitization and Big Data

Digitization will have a similarly far-reaching impact upon many aspects of our social, private and public lives as the invention of the steam engine (cf. Brynjolfsson/McAfee, 2014, p. 6 ff.). We differentiate between three levels of digitization.

The "digital world" describes how the business world of the future will look. It is characterized by new digital or digitally enhanced business models, as well as by a newly designed value chain from the customer via production through to delivery of the good or service based on the credo of the on-demand economy. At the same time, this both requires and facilitates a digital performance management model for companies which results in far more efficient and differentiated performance management.

Data, together with quantitative models to convert it into useful information and solutions, are the "digital engine" which drives the developments leading to the digital world. The engine is powered by the generation and availability of nearly unlimited information about our world. In the broader sense, we interpret Big Data to be all the information in the world, while in the narrower micro-economic sense we see it as all the data that a company can use for management and development purposes (cf. e.g. also Davenport, 2014). This includes both internal and external, structured and unstructured data. The interaction between technological developments, methodology approaches and innovative mathematical-statistical models is laying the foundations which will enable us to utilize the potentials of digitization both today and tomorrow, and the speed it is doing so is increasing exponentially (cf. Brynjolfsson/McAfee, 2014, p. 37 ff.).

In the meantime, developments in technology, organization and methods have reached a level of maturity which allows for the implementation of hitherto theoretical concepts in the digital reality at an ever-increasing pace. The spread of digitization and the growth of Big Data are both exponential in nature and we have only experienced the flat part of the spread function, while the steep part is only just unfolding. For companies, the overarching question today is how to harness the potentials of these two developments quickly and effectively, as they have truly Schumpeterian power.
2. The Power of Big Data

Using Big Data for analyzing, forecasting and optimizing all business activities requires a consistent overall concept.

These four levels summarize the major success factors for utilizing Big Data. Any strategy which focuses on the intensive use of data as a core element of corporate performance management must systematically develop these components. For example, the Internet of Things (IoT) generates its data contribution via sensors in products at the lowest level. The core layer of value creation from data is the modeling level. Here, data integration, data preparation, system modeling and machine learning take place. At the data processing and storage level, bandwidth and processing power itself are the greatest challenges. At the fourth level, visualization is crucial to effectiveness in using the information gathered in the form of decisions. Without comprehensive visualization, the value created by the fourth production factor is incomplete.

The quality of the management information extracted from Big Data depends on the availability of comprehensive, multi-dimensional, high-resolution data. Big Data is basically the whole world of information. The practicality of such a comprehensive definition of Big Data becomes clear when we regard a company as a complex system and reflect this consistently across all the available data dimensions. Very quickly we are faced with the question of where to set the boundaries of the system, basically of the company. A simple example here is the variable “weather”. Five years ago it still played a rather minor role for many companies whereas today we can measure the influence of this variable in virtually every corporate model based on its direct impact. Hence, in the age of Big Data the narrow definition of classical driver models can be substituted with global variables models.

The reason mathematical performance management models are so important is because complex systems cannot be compared directly with one another or be “offset” against each other in an Excel spreadsheet. We need association and causal models to visualize and evaluate complex relationships. In most cases, pure correlation models are not up to the task of strategic decision-making and many types of scenario modeling. They provide no information about the causal relationships between the variables themselves in the sense of a classical driver model and thus offer no clear approaches to performance management.

Operative and strategic performance management models can be broken down into three categories based on their informative value:

- Models with a high degree of explanatory power are models which describe themselves and the system they portray (e.g. a company, a function, a process) sufficiently accurately and in a way which people understand, and in doing so describe the entirety of the system’s function and impact.
- Predictive power describes the ability of models to make predictions as far into the future and as accurately as possible.
- Control power describes the ability of a model to use a sufficient number of sensitive control variables for interactive support in strategy definition, scenario modeling and simulations.

A further paradigm shift concerns machine learning. Generally, classical models of corporate performance management are linear, pseudo-deterministic and static. They do not become better through the data they use and thus cannot improve their informative value unless people change the model. With Big Data the changes and learning are not carried out by people but by the algorithms, by the machines. Algorithms develop model structures and model parameters with the continuous incoming stream of data and actually evolve themselves (genetic algorithms).

This changes the interaction between humans and machines. While until recently it was the controller or analyst who used the functions for data mining and analysis, now the machine assumes many of these activities. The balance of decision-making is tipping rapidly towards the machines. Already today the majority of decisions for many operations activities are being taken by algorithms, like for example automated procedures or algorithm-based trading in securities and bonds or digital advertising. We would like to use two examples to demonstrate the possible uses of Big Data models and algorithms and to show how effectively they can perform.

Example: "Optimizing a logistics network"

A logistics network for the interim storage and transportation of raw materials and semi-finished products which is mainly demand-driven should be optimized so the transport quantity is maximized and the necessary transport capacity is minimized. There were several gigabytes of system data available for a model-based optimization of the logistics network with over 400 variables and approximately 50 boundary conditions under which the network had to function. The objective was to design an optimized planning and performance management model with which different target models could be simulated to test their impact on transport quantity and transport capacity.

Two target models were defined using special network models and learning algorithms. Using those models it was possible...
to either reduce idle capacity by 24 percent or in the alternative model increase transport capacity by 21 percent under the given boundary conditions. Using complex simulations in real time it was possible to question some of the restrictive boundary conditions of the operating system and achieve an efficiency potential of over 30 percent.

Thus, Big Data is the fuel for the performance management and decision-making models of the future. Thanks to Big Data companies can be described accurately as complex systems as they interact with other such systems where all of them are embedded in layers of surrounding systems from markets to societies and nature with its limited resources itself. With these models at hand, companies are enabled to manage themselves at the next level of complexity that our societies and economies have reached. Companies without these instruments will not be successful in the fully digitized and interconnected data-driven world of tomorrow.

Figure 3 illustrates the complexity of optimization problems. Each node represents a loading or unloading station. The bigger the node, the more frequently the station is used. During the course of the simulation lasting several hours, the charts provide images of the interim steps of the optimization, providing additional information about the efficiency of the models and the algorithms. In this example the amount of data was not the decisive factor, but the sophistication of the model’s concept and its algorithms. More data without a better algorithm very often just leads to more noise.

Example: "Developing a safe traffic policy"

A second example is the development of a strategy model to simulate and model a safe traffic policy. The objective of the policy is to minimize personal injuries resulting from accidents without bringing traffic – an important economic factor – to a standstill.

Based on approximately eight million data sets from traffic accidents gathered over a period 40 years, a causal model was developed to analyze, predict and model a comprehensive traffic policy strategy that would lower injuries and casualties whilst safeguarding traffic efficiency. The target model used approximately half of the 60 variables and achieved a predictive accuracy of over 94 percent (cf. Fig. 4).

Using the model, it was possible to develop twelve different policy strategies, test their impact on traffic safety and verify their economic feasibility. In this example, the objective was to achieve an acceptable balance between traffic flow, the successive reduction of personal injuries and, of secondary importance, of material damages. Without the latest modeling instruments and machine-learning algorithms, devising such a comprehensive traffic policy strategy would not be possible.


Over the next few years, technological and methodology enablers will lead to the breaking down of more and more barriers to the use of data. From the technical perspective, it will be possible to carry out every type of analysis and forecast based on the most comprehensive and multi-dimensional data pools. The limits on the technically feasible use of data will have to be set based on ethical aspects, data protection regulations and corporate strategies.

Digitization opens the door to raising the finance function to a whole new level of efficiency while at the same time massively increasing the quality, speed and relevance of the information supply.

The gains made in efficiency must be used to develop the CFO function to play a much stronger role as a business partner which creates value for the company. If companies do not successfully make this transformation, some of the major components of corporate performance management, such as deviation analyses or decision-making support, will be shifted to the functions themselves and controlling will be reduced to merely supplying information.

We have developed ten central theses which describe how these potentials can be manifested and realized in the performance management system of a company, thereby creating a “digital finance function”. In all, the changes presented here represent a significant change on all levels of an integrated corporate performance management system (cf. Fig. 5).
changes require a significant shift in the mentality, self-image and skillsets in controlling and finance. For a more detailed discussion, see Kieninger et al. (2015).

**Fundamental changes in the performance management processes**

1. **There is a paradigm shift in performance management from reactive/analytic to proactive/predictive**

Big Data and predictive analytics are used to generate automated forecasts from granular data which are more accurate than traditionally created forecasts. Based on these more accurate forecasts, companies can develop forward-looking measures in order to have a positive influence on the forecasted development.

2. **Quantified business and driver models form the foundation of a new performance management**

Qualitative deterministic driver functions are replaced by machine-learned models and continuously improved with every new data set generated. Robust, rules-based business models serve as the foundation for scenario planning, for quantifying strategic options and for evaluating business cases. Management means assessing chances and risks and taking “optimal” decisions in the face of uncertainty. Big Data, in connection with innovative analytics reduces uncertainty by providing considerably more detailed and comprehensive fact-based information for decision-making.

3. **Performance management cycles and optimizations are agile, real-time and based on concrete suggestions for improvement through data analysis**

Automated analyses reduce reaction times, enable “high frequency decisions” and lead to the ongoing identification of possible optimization measures. Analytical applications search the data pools automatically for potentials, e.g. via correlation or causal models, and open up an additional dimension in the search for improvement.

4. **Performance management becomes more automated, multi-dimensional and multi-functional**

Decisions within defined value and risk boundaries are automated based on the probabilities of forecast results (e.g. for merchandise planning in retailing or for price adjustments). Generally, decisions are taken more quickly based on quantitative, differentiated findings and recommendations. At the same time, risks are integrated in the analysis models while considering cross-function interdependencies (cf. e.g. Feindt/Grüßing, 2014).

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**Fig. 5: Influence of digitization on the core elements of the performance management system**
5. Processes are managed across company functions and the supply chain

Digitization enables cross-functional supply networks across the whole company within which information is shared across the internal and external borders of the organization. Increasingly, controlling must be a process which covers both internal and external aspects regardless of legacy boundaries.

Basic conditions underlying the changes

6. Big Data analytics is a separate field of competence with highly skilled specialists

A new and expanded skill set is needed to utilize the potentials of Big Data: Data scientists and quantitative business modelers are new roles with advanced competencies essential for the management of enterprises and the development of new products and services. Steering labs and data science centers will become an important success factor for the management and research and development functions alike. The controlling function will have to make sure that they can at least tap into those important centers of expertise which for many years will see an excessive demand for their supply of skills and competencies. The finance function will have to team up with the other corporate functions to create these centers and ensure that their topics are sufficiently covered by QBM centers.

7. The role, organization and employee profiles in the finance function are changing

The CFO will develop even more strongly towards being a chief performance officer. Controllers use the analytical findings to optimize operative processes and continuously expand their role of business partner (cf. Grönke/Heimel, 2015). At the same time, the finance function will be organized strictly along the lines of transactional and analytical processes: Finance factories and steering labs complement one another.

8. Steering with probabilities: The quality of data generation, modeling and analysis determines the quality of decision making

The quality of the data and the methods is a major determinant of the quality of the results. One important task is above all to ensure the quality of the external data, although it is also crucial to use the right algorithms and to ensure they are continuously optimized. A key success factor will be to develop and maintain the complex models.

9. Internal and external data must be made available and accessible on a granular level

Raw data of high granularity forms the basis for the statistical models. This data can be consolidated into a KPI through many stages of preparation and analysis. The crucial factor here is that the data from both internal and external and structured and unstructured sources, including market and customer data, is available with source level granularity. While the informative value of machine models depends on granular data, people can only extract information and make decisions based on strongly aggregated data. Until now, ERP and performance management systems have been designed to create usable information as quickly as possible by strongly aggregating data.

In the future, performance management systems must serve both “users”: humans and machines. In-memory databases facilitate precisely this and in the future they will provide data with the highest possible granularity to form the foundation for performance management information.

10. Strong central governance for data and models is the most important success factor for consistent, end-to-end performance management

Companies need governance which is extensive and which works in order to ensure the data and analysis models are both compatible and consistent. The finance function must clarify and organize the sovereignty and the responsibilities and ensure they are transparent to all involved. The governance regulates the scope, quality and availability of the data and thus by definition the quality of the results generated by the analysis models.

Digitization has a radical impact on all dimensions of the finance function. In the eyes of many of those in charge, digitization might still seem like a black box. Accordingly, it is important to develop trust in these new approaches and their results continuously and successively. For this, it is necessary to consistently build up the required skill sets among employees. Additionally, it is vital to communicate the benefits to all levels of the company and to ensure data security, data consistency and sustainable governance.

4. How Controlling Can Embrace Digitization

As in other functions and the company as a whole, the CFO function will be heavily impacted by the changes caused by Big Data and digitization, but these changes also represent a great opportunity. Naturally, there is also a whole series of dangers, not least of which is the risk of paralysis by analysis of the current development and thus by starting too late and thereby missing out on learning by developing these new methods, instruments and processes offered by digitization. CFOs must find and define the best way for their function to “steer business digitally”, one which suits the specific, individual situation of their company. There are a number of approaches which have proved successful here, approaches which can be adapted individually or in combination to suit the specific needs of a company.

Digital CFO Strategy and Strategic Use Cases

A target picture of the digitized finance function is developed in a strategy process. The path to the target picture is operationalized in the form of a roadmap using strategic and operative measures. Special attention is paid to creating concrete use cases which promise the greatest and fastest benefit for the company.

Digital Readiness Assessment

It can be beneficial to carry out an assessment of the digital maturity of the finance function, ideally as part of the strategy development process. This allows the company to systematically derive measures which will lay the foundation for data analytics, for example, and to realize the use cases it has created.
Pilot Applications
Pilot applications are very well suited for evaluating the potential of digital approaches, e.g. in analytics or in predictive applications, and for gaining experience. This can be in the aforementioned use cases defined in a systematic strategy process or in application scenarios which are driven by the problems arising in a current situation.

SAP S/4 HANA and Simple Finance
The motivation for switching to in-memory technologies and the new concepts of SAP S4 is primarily to optimize operative performance management and less due to digitization aspects. In-memory technologies provide data on a granular level, thereby enabling its direct use in mathematical-statistical methods. In conjunction with the extensive potentials for optimizing the value chain in the finance function, this approach is an important building block for digitizing the CFO function.

5. Summary
Digitization has triggered a real paradigm shift in corporate performance management. The main drivers are the potentials inherent in Big Data and the quantitative models for generating information and making decisions. The changes will impact upon both the senders and the recipients of performance management information and, in all, this will create a completely new understanding of the performance management instruments in established use today. In future, all relevant performance management dimensions, such as customers, markets or resources, will be able to benefit from the added value created by the developments in technology and methods and the applications they have enabled. To do this, however, requires companies to systematically create the necessary conditions. Only by leveraging all potentials digitization and Big Data offer and by addressing the necessary changes pro-actively and openly will companies be able to reap the digital dividend in the coming years!

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Further literature from the online archive of CONTROLLING:
Abstract

Digitization has a major impact on Controlling. The primary driving force is the utilization of Big Data through mathematical-statistical models. Already today these models facilitate new management and optimization approaches and their future advancement is rapid. The resulting changes lead to the target picture of digitized performance management.

Imprint/Contact

Editor
Horváth & Partner GmbH
Phoenixbau | Königstraße 5
70173 Stuttgart
Tel.: +49 711 66919-0
info@horvath-partners.com

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