solvice

Current state of workforce scheduling
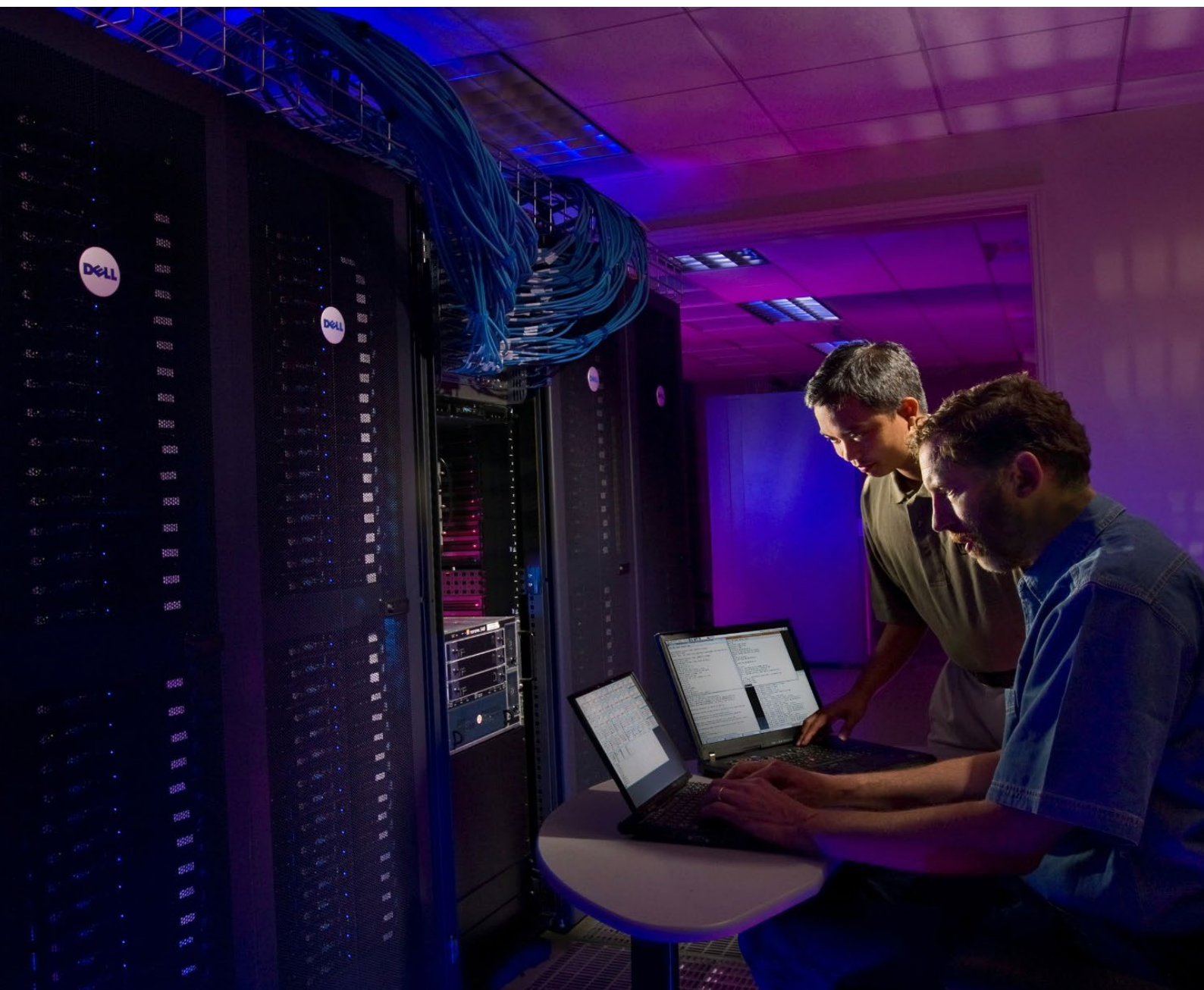
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Executive summary

Artificial Intelligence (AI) is everywhere today. It is attributed the most talked-about characteristics and the use of AI is already disrupting entire industries. By now, everyone has heard of smart thermostats, image recognition and autonomous driving, but can we also apply this technology to workforce management?

In this report, we reveal some of the added value of AI for workforce management. We start with a brief introduction to the different domains within AI. We will try to explain it in clear terms, without using the usual hype terms and invariably the same, too general, examples. Afterwards, we will look at how the algorithms from these domains can be applied to workforce management. We then introduce our approach and why this makes us different in this field. Finally, we address the specific benefits of using AI for workforce management with a detailed discussion of three application areas.

The first application area relates to determining long-term workforce capacity. We show how AI can contribute to a holistic approach to workforce planning. AI-based suggestions can help HR managers to control workforce costs when drawing up a strategic plan, while keeping in mind the desired service level and the defined ambitions for the future.

The second application area we highlight in this report is the tactical forecasting of workforce requirements. Recent AI innovations allow for significantly more accurate forecasting. We demonstrate how these improved forecasts can lead to better decisions that make it possible to maintain the balance between cost efficiency and customer satisfaction.

S. J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 3rd ed., Upper Saddle River, NJ: Prentice Hall (2010). Christopher M. Bishop, Pattern Recognition and Machine Learning, New York: Springer (2006).
Pettey, C., & van der Meulen, R. (2018) https://www.gartner.com/technology/pressRoom.do?id=3872933.
Retrieved from www.gartner.com./ https://www.gartner.com/technology/pressRoom.do?id=3872933

The final application area of AI in workforce management that we describe in this report, is autonomous workforce scheduling. Autonomous scheduling aims to minimise the difference between the forecast required workforce levels and the effectively scheduled shifts. We show how automatic provision of optimal work schedules and real-time adjustment and optimisation of scheduling yields measurable benefits compared with today's time-consuming (often manual) planning process. The main benefits are in the areas of employee productivity and satisfaction, workforce costs and compliance with laws and regulations.

AI, Machine Learning and Workforce Management

Artificial intelligence is currently changing the world and the way we work, including in the area of workforce management. It is time to understand why. This section introduces the key domains within AI.

WHAT EXACTLY IS AI?

Artificial Intelligence cannot be reduced to a single algorithm or even to a defined uniform area. As a result, its description is often ambiguous and often the reader can no longer see the wood for the trees. We try to characterise AI as the collection of all domains in computer science that tackle problems traditionally associated with human intelligence. Some of the domains that increasingly often show up in the news about AI include Computer Vision, Natural Language Processing (NLP), Machine Learning (ML) and Optimisation.

These last two domains warrant a closer look at since they are the ones where we can demonstrate the highest added value within workforce management today. Specific to both domains is the use of methods that recognise patterns in data. Within Machine Learning, the following methods are used for this purpose:

▸ **Unsupervised Machine Learning**, where data is analysed to extract patterns that best generalise the data. We use this technique mostly in an explorative phase, allowing the data to be divided into clusters.

▸ **Supervised Machine Learning**, this is by far the most used form of Machine Learning. The algorithm contains both an input (e.g. images) and the desired output (label). This allows the algorithm to learn to assign the input to an output. A well-known example is an algorithm that is able to distinguish between a cat and a dog. This is done by analysing hundreds of images of cats and dogs, each labelled 'cat' or 'dog'. We use this method in predictions, classification or recommendations.

▸ **Other techniques or variants** of the above include semi-supervised learning (a mix of the two methods described above) and reinforcement learning, where the algorithm is not given an output or a label, but only an indication of the extent to

Erin Winick, 'Every Study We Could Find on What Automation Will Do to Jobs, in One Chart,' MIT Technology Review (January 25, 2018), retrieved from www.technologyreview.com https://www.technologyreview.com/s/610005/every-study-we-could-find-on-what automation-will-do-to- jobs-in-one-chart/.

which the output is achieved or deviates. This allows the algorithm to learn the best strategy to achieve an output or goal.

In turn, within optimisation we identify two classes of algorithm, including:

▸ **Mathematical programming**, a method that uses mathematical modelling to simulate a real-world problem. This method is often used to guarantee the best possible result under predefined conditions.

▸ **Heuristics**, a method to solve a problem quickly when other methods are too slow.

AI AND WORKFORCE MANAGEMENT TODAY

Workforce management encompasses a wide range of activities: time recording, planning, volume forecasting, payroll, redundancies, re- cruitment, and the various other aspects of modern workforce admin- istration. While traditional AI approaches have long been used in some parts of this domain (for example, stochastic search methods used to generate schedules), more advanced AI has only just entered the mar- ket, according to Facebook's Chief AI scientist Yann LeCun.

To demonstrate the benefits of the methods discussed, this document focuses on three application areas where AI adds significant value to supporting decisions in workforce management.

1. **Strategic Workforce Scheduling**
   Managing a workforce over the long term is no easy feat. Due to fluctuating needs in the workforce, it is important to take action at the right time by recruiting, training, outsourcing or laying off staff. To support these decisions correctly, simulations are created using scenario analyses in combination with optimisation methods.

2. **Forecasting workforce requirements**
   Forecasting a company's workforce requirements on any given day is often associated with uncertainties and inaccuracies. A suitable solution to this problem is the use of a supervised ML, which can produce highly accurate forecasts based on more factors and data sources than the current, more traditional methods.

3. **Automatic employee scheduling**
   Workforce scheduling in an operational schedule is a time-con- suming and frustrating task for all parties involved. An intelligent optimisation algorithm is able to generate a perfect work schedule, given the forecast workforce. This schedule satisfies all complex employment contracts and preferences, while minimising expect- ed under and overstaffing.

Teigland C.L. (1991) Workforce Analysis and Turnover Forecasting: Building Capacity in New York State Government. In: Nie- haus R.J., Price
K.F. (eds) Bottom Line Results from Strategic Human Resource Planning. Springer, Boston, MA
Eadicicco, L. A. (2019, 18 February). 3 things we learned from Facebook's AI chief about the future of artificial intelligen- ce. Consulted7
at https://www.businessinsider.nl/facebook-artificial-intelligence-yann-lecun-2019-2?international=true&r=US

Approach & Differentiation

Through our approach we help you to be even more successful by introducing data-driven decision-making in all layers of your organisation.
We make businesses more efficient, predictable and effective using our specialised advice and products.

OUR APPROACH

We identify the challenges.

The path towards data-driven decision-making starts with understanding the current situation. Working together with experts, current processes are analysed and opportunities identified. We subsequently investigate the potential impact of these new opportunities.

We show the added value.

Once the greatest opportunity has been chosen, we create a business case based on the current situation. Our experience and knowledge in these specific domains enable us to quantify the opportunity and create support for the next steps.

We prove the added value.

To further develop the added value, we present a Proof of Concept (PoC) within 10 days, in which we explain the opportunity in detail. This is how we prove the Return on Investment (ROI) that can provide a solution and we present a first implementation that can be scaled up in the next step.

We start the project

The starting shot; from this moment on we realise positive changes in your processes. Moreover, during the implementation we support the chosen solution from A to Z.

We keep improving

Once the implementation has been completed, we continue to monitor the quality of the solution, constantly perfecting the results and making adjustments where necessary. In addition, we start a data-driven feedback cycle to embed continuous improvement in your process.

WHY SOLVICE?

Solvice invests in advanced technology and innovation through AI research. Based on this, we create practical solutions that respond to current problems. An example of such a solution is our OnShift API, which is used for automatic workforce scheduling. Below we discuss three points that illustrate the basis for creating practical solutions.

✓ **An innovative infrastructure.**
We do not limit ourselves to the cloud, but build on it using our own AI architecture, powered by big data. This enables us to automatically scale-up computing power and meet all the computational requirements of the cutting edge AI applications we put into production at our customers.

✓ **Using our in-depth expertise.**
The most important part of any AI solution is the choice of algorithms to implement and the analysis of their representativeness. This requires not only extensive knowledge of the algorithms, but also of the business problems and their domain. Our experts can draw on their experience for the following questions, for example: What are the 15 most important functions for forecasting volume in a fortnight?
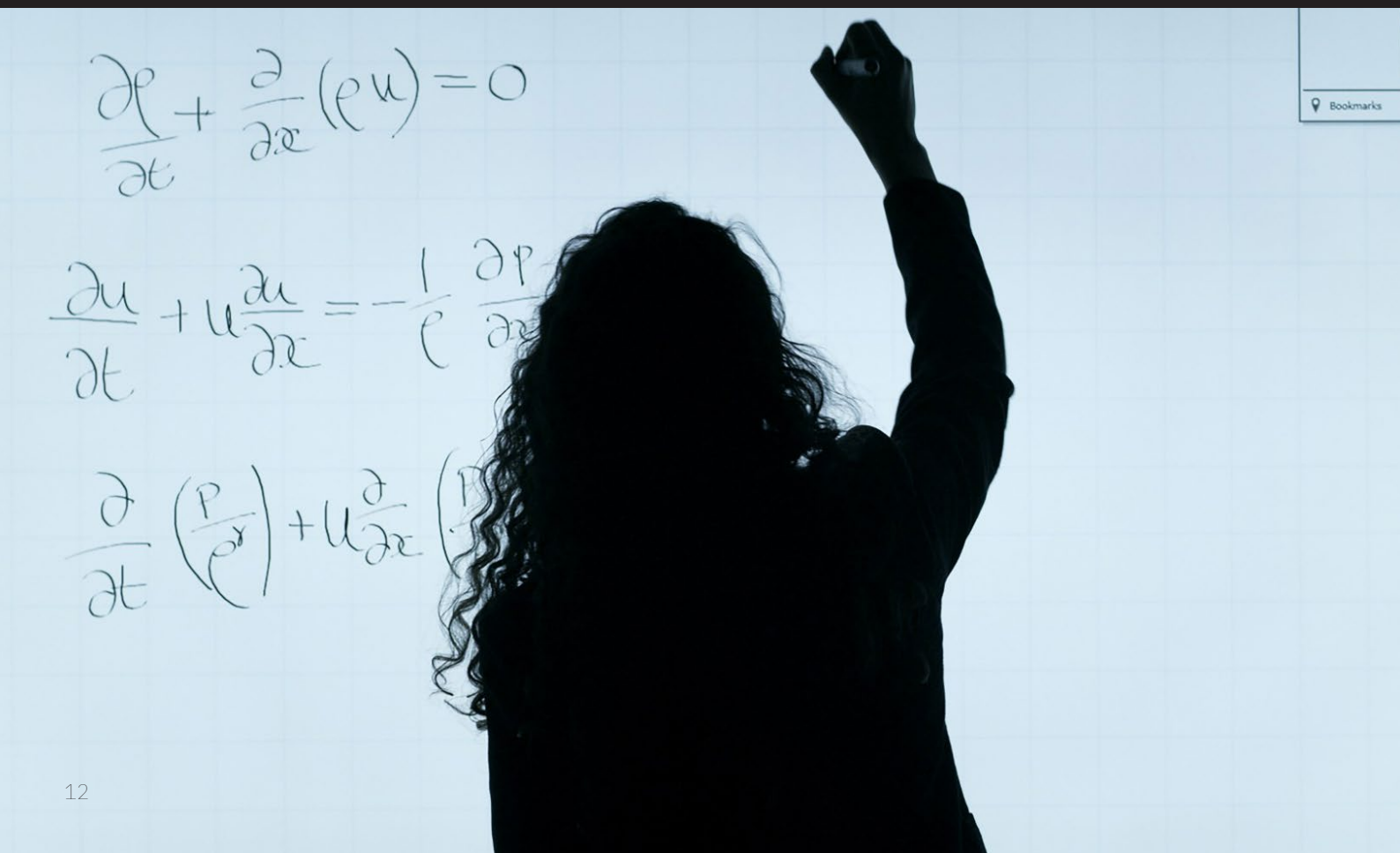
Which six indicators best reflect the risks associated with observing the timetable?

✓ **Testing and fine-tuning using real data**
As mentioned in our approach, Solvice works with its clients to test AI solutions on real data prior to implementation. This ensures critical testing, design verification and quantifiable confidence in the solution.

Workforce Management AI application areas

The objective of workforce management is to increase employee productivity. The planning process is divided into strategic (long-term), tactical (medium-term) and operational (short-term) phases.

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) = 0$$

$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} = -\frac{1}{\rho} \frac{\partial p}{\partial x}$$

$$\frac{\partial}{\partial t}\left(\frac{p}{\rho^\gamma}\right) + u \frac{\partial}{\partial x}\left(\frac{p}{\rho^\gamma}\right)$$

Bookmarks

HIERARCHICAL PLANNING LEVELS

1 Strategic — **STRATEGIC CAPACITY PLANNING**

2 Tactical — **FORECASTING WORKFORCE REQUIREMENTS**

3 Operational — **AUTONOMOUS SCHEDULING**
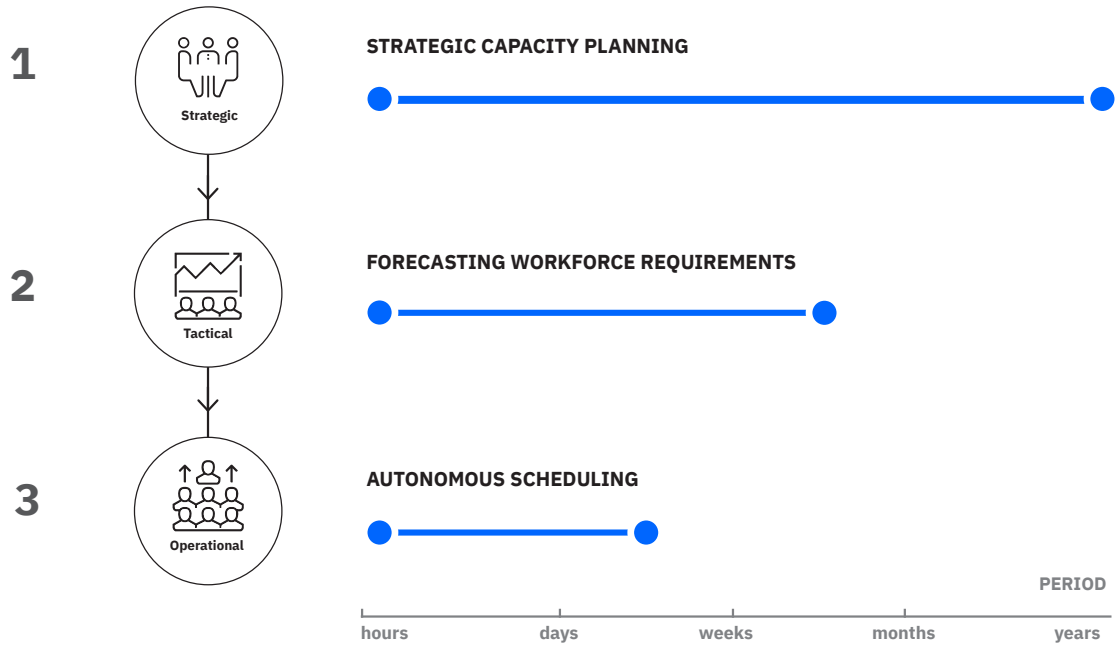
PERIOD

hours   days   weeks   months   years

Figure 1: The 3 levels in workforce scheduling

1 STRATEGIC CAPACITY PLANNING

Matching supply and demand by deploying the right employee at the right time and in the right place.

What does an ideal workforce look like? On a strategic level, it is essential for any organisation to have insight into the total workforce costs, the distribution of the workload and recommendations for staffing. At Solvice we respond to this demand by managing long-term changes in the demand curve (workforce requirements) in the most cost-efficient and robust manner.

CHALLENGES IN THE STRATEGIC PLANNING PROCESS

Organisations use budgeting to determine their annual, quarterly or weekly workforce costs based on anticipated workload. These budgets typically include historical averages of turnover, a growth factor and a forecast of labour costs. This allows organisations to easily calculate the cost of their employees by multiplying the number of hours worked by the cost of each employee.

However, this is quite a challenge when realistic changes must be considered. These changes have an impact on the workforce and ultimately on the total budget. Frequently asked questions include: What if I open a new branch? What if I invest in new technology that changes my working conditions? What if the minimum wage is rising and I want to save on increasing workforce costs? How to get the right mix of employees to respond to different long-term trends and tendencies?

OPTIMISING THE WORKFORCE BUDGET WITH AI

Dealing with all the uncertainty and all these future scenarios quickly becomes an almost impossible task, where AI can help to simulate such scenarios. We use AI to reduce this complexity in seconds. We

reduce the inefficiency of manual calculations by making the input dynamic and creating 'what if' scenarios. We take into account multiple factors, such as the costs associated with new employees and over or understaffing in relation to workforce requirements and calculate the required capacity utilisation for each week of the budgeted time frame. Figure 2 is a schematic representation of the inputs, outputs and restrictions an AI application for strategic capacity planning can take into account.

A clear picture of the future workforce allows building an ideal workforce - one that is optimised to reduce unnecessary workforce costs, minimise missed commercial opportunities and manage workforce fluctuations. In addition to creating the ideal workforce, we provide a more realistic and faster input into the workforce budgeting process. We believe it is essential for your organisation to gain in-depth insights into strategic capacity planning in order to remain efficient in the long term.

VOORDELEN VAN AI VOOR STRATEGISCHE CAPACITEITSPLANNING

▸ **Manage competencies.**
  Manage long-term workload by focusing on the right competencies at the right time. Respond to a change in long-term workload by closing a gap in the workforce and recruiting at the right time.

▸ **Analyse the impact.**
  Analyse the impact of different scenarios (affecting future staffing) on your organisation's workforce. Use AI to do the hard work and run these simulations accurately and quickly.

▸ **Anticipate future fluctuations.**
  Anticipate future fluctuations in workforce requirements by taking into account constraints, costs and efficiency. Determine whether additional personnel should be recruited, trained or outsourced within a company.
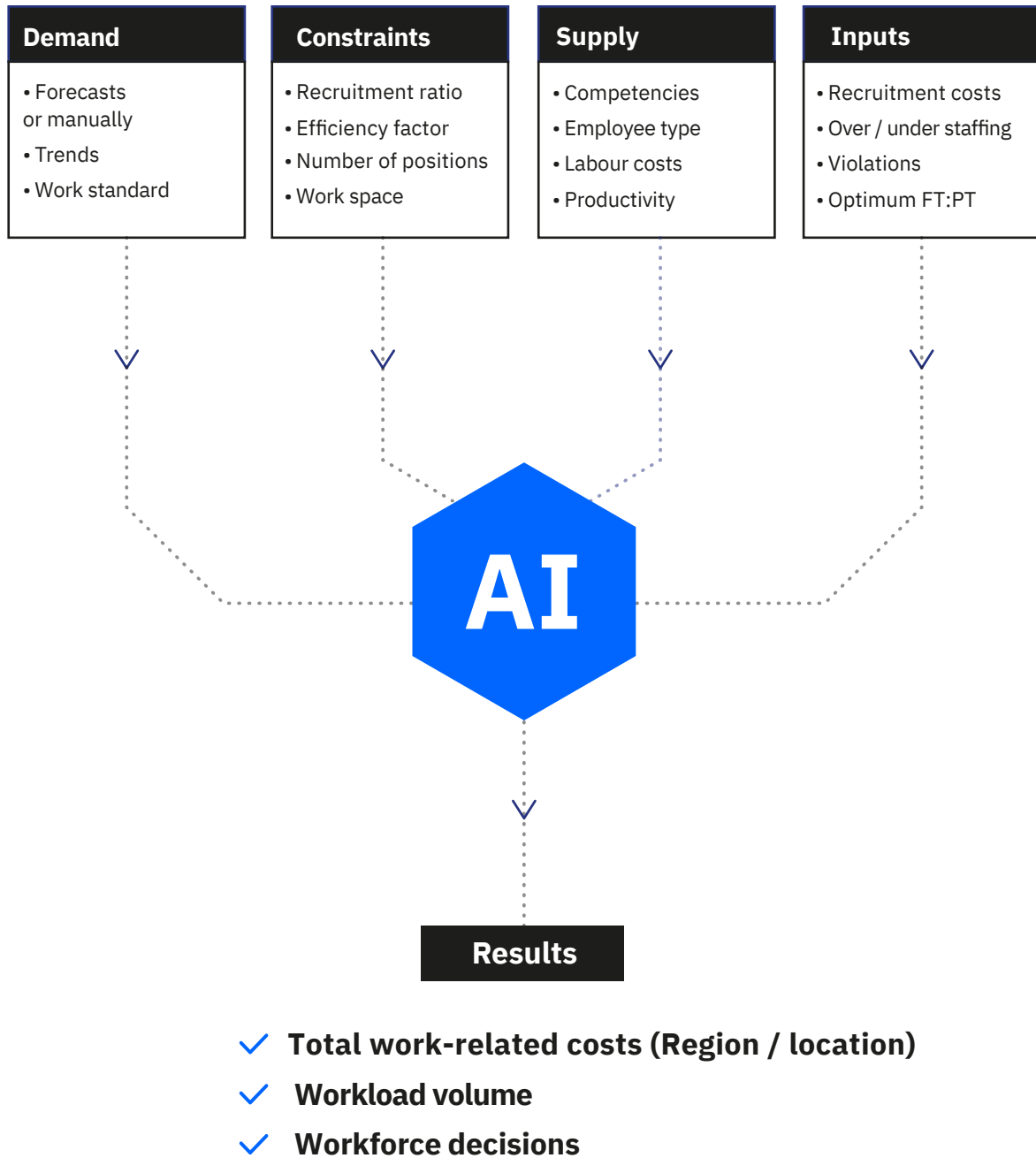
Demand

• Forecasts
or manually
• Trends
• Work standard

Constraints

• Recruitment ratio
• Efficiency factor
• Number of positions
• Work space

Supply

• Competencies
• Employee type
• Labour costs
• Productivity

Inputs

• Recruitment costs
• Over / under staffing
• Violations
• Optimum FT:PT

AI

Results

✓ **Total work-related costs (Region / location)**

✓ **Workload volume**

✓ **Workforce decisions**

Figure 2: Schematic representation of how AI brings together supply and demand

2 FORECASTING WORKFORCE REQUIREMENTS

Consider both the near and far future and forecast the ideal workforce.

Workforce planning in any organisation very much relies on the accuracy with which the workforce demand can be predicted. Statistical formulas or rules of thumb have long been used for this purpose, but recently technological innovations in supervised ML, deep neural nets and tree ensembles methods have been offering even more possibilities. Such innovations allow forecasts to be even more accurate and realistic, while requiring increasingly less manual fine-tuning or interventions.

AI FOR FORECASTING WORKFORCE REQUIREMENTS

At Solvice, we use these methods to meet the demands of companies in retail, hospitality, healthcare, logistics and various other sectors in collaboration with our WFM partners. Below we explain some of the characteristics that allow us to make more accurate predictions.

Feature extracties

Figure 3: Feature extractions

▶ **Extensive data features:** Various data sets, such as current averages, long-term trends, calendar data, organisational structure, special events, location data and weather information enable the model to identify complex seasonal, weekly or organisational patterns.

▶ **Data pooling:** Specific techniques combine data from different locations to detect similar departments and make predictions at the same time. Thanks to this big data technique, this constitutes a shift from isolated departments to an integrated approach across the entire organisation or even across multiple organisations.

▶ **Distant horizon:** It is possible to look further into the future than before, with higher accuracy. Innovations in machine learning make it possible to go further, where traditional methods lose their accuracy and usefulness.

▶ **Depth of variables:** Our AI is trained to process both large and small volumes. From a high-level controlling variable (such as total sales or market forecasts) to a lower level (such as the number of glasses of beer in a restaurant or the number of unique visitors).

BENEFITS OF AI FOR FORECASTING WORKFORCE REQUIREMENTS
Combining these innovations with a powerful supervised ML regression technique offers some benefits:

▶ Our Machine Learning methods show an average improvement of 20% over traditional formulas such as moving averages, historic naive predictors or rules of thumb, for a wide range of industries.

▶ Compared to more traditional methods, a well-trained ML model is less sensitive to bias and outliers.

▶ In contrast to traditional statistical methods, Machine Learning methods can be expanded more easily; the inclusion of new data features that affect volume do not require manual intervention in the model or mathematical formulations.

▶ By automatically retraining the model, Machine Learning algorithms can autonomously adapt to new customer data or new trends.

TRAINING   FORECAST

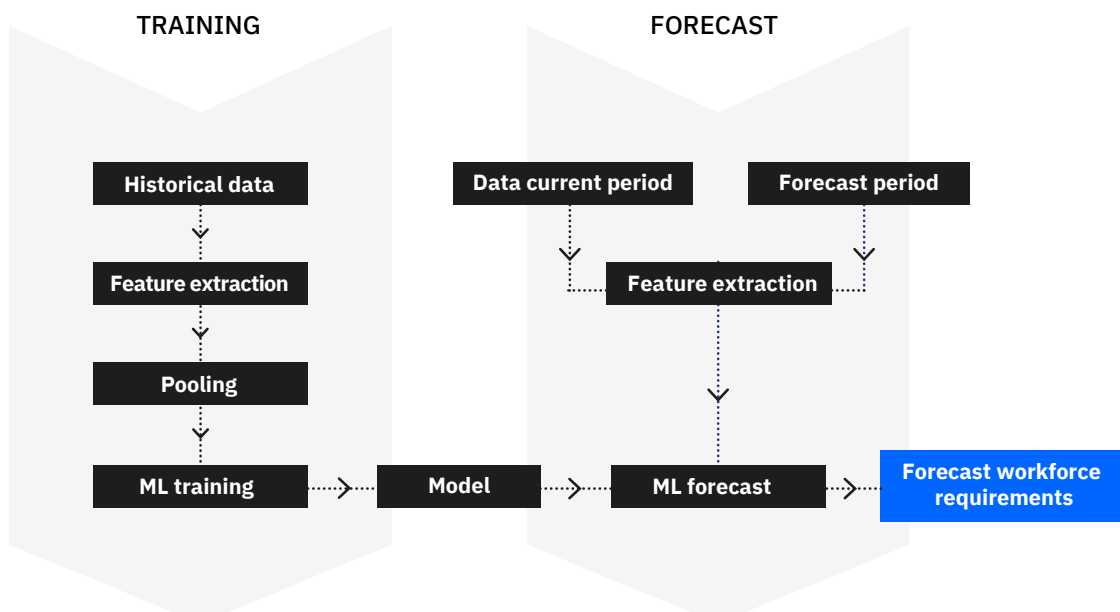| TRAINING		FORECAST	
Historical data		**Data current period**	**Forecast period**
Feature extraction		**Feature extraction**	
Pooling			
ML training	**Model**	**ML forecast**	**Forecast workforce requirements**

Figure 4: AI Design to train and apply a model for workload forecasts.

Figure 4 shows a schematic representation of the logical steps and characteristics that are typically used in the development, training and execution of ML algorithms.

Experience shows us that ML algorithms consistently produce better forecasts than the more traditional methods that are commonly used. In the table above, we highlight two examples of companies for which we have used ML algorithms.

We describe the outcomes obtained by a company in the hospitality and retail sectors. The second column shows the percentage of departments or branches for which we managed to create better forecasts based on an ML algorithm. The third column shows the improvement in percentage points of the new predictor compared to the method previously used.

Sector	% of departments improved	% improvement
Horeca	92%	21%
Retail	91%	18%

3 AUTONOMOUS SCHEDULING

Make adjustments in real time, the scheduling is self-optimising.

WHAT IS AUTONOMOUS SCHEDULING?

The automatic and optimal scheduling of employees for a specific work schedule is referred to as autonomous scheduling. It is only optimal if it can be demonstrated that there is no better solution given the constraints and advantages.

The academic literature on AI for autonomous scheduling considers two different methods to arrive at an ideal solution: heuristics and mathematical programming. Heuristics are efficient methods able to quickly generate a solution using sector-specific knowledge. Mathematical programming, on the other hand, uses mathematical modelling of the problem to generate an optimal solution without guaranteeing the speed of the algorithm.

The absence of guarantees for the quality of the solution does not mean that a heuristic method has no place in AI. Heuristics are an ideal way to create a starting point for algorithms to further optimise the result, but heuristic methods alone will not produce the best results in most cases.

Moreover, autonomous scheduling is self-learning and takes into account the different objectives while allowing for adjustments to be made where necessary.

BENEFITS OF AUTONOMOUS SCHEDULING

Autonomous scheduling not only eliminates the frustrations typically associated with the planning process, but it also results in better planning than manual or semi-autonomous planning. Better planning results in an increase in customer satisfaction, more commitment from employees, lower costs and fewer violations of labour laws, among other things:

- ▸ **33% higher productivity:** By better matching supply to demand and thus minimising both under and overstaffing, employees are used efficiently.

- ▸ **14% lower workforce costs:** Automation of the entire planning process reduces the time spent by the manager on scheduling.

- ▸ **30% fewer violations of rules:** Constraints such as legal regulations, working conditions, union regulations and company rules are included in autonomous scheduling and are not violated.
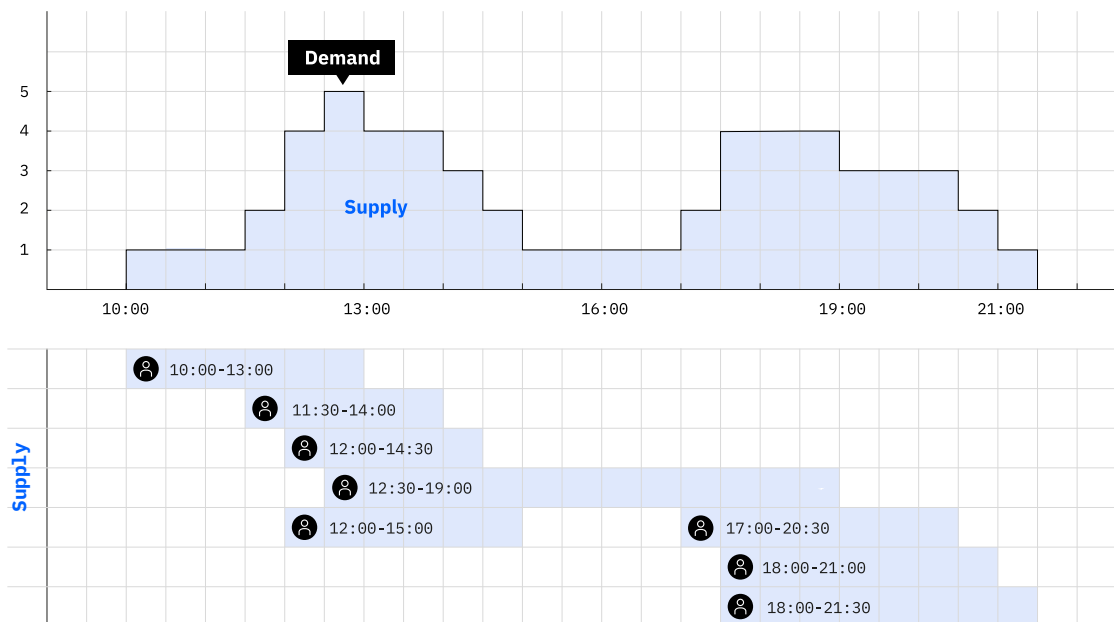
Figure 5: Matching supply and demand

HOW TO SET UP AUTONOMOUS SCHEDULING?

Setting up effective autonomous scheduling can be divided into 2 phases, which may or may not be combined:

1. **Creation:** Automatically generate the correct shifts for each department, based on the role and skills of the workforce. The purpose of these shifts is to serve the customers of an organisation within a targeted service level, while respecting the relevant company rules.

2. **Assignment:** Assign employees to these shifts depending on their role, skills and contract type. An effective optimisation algorithm, such as ours, takes into account multiple parameters such as employees' own preferences and, moreover, prevents labour law violations.

Thanks to intelligent optimisation algorithms for autonomous scheduling, rules of thumb are no longer needed for planning. Ideal schedules are created on the basis of a demand curve (workforce requirement) and the workforce (i.e. different employees characterised by their preferences for starting and finishing times, level of experience and costs). We minimise the total number of shifts and overtime, while finding the best possible balance between customer service and workforce costs.

The optimisation algorithms automatically assign employees to shifts, taking into account the employees' preferences, HR policies and labour laws, among other things. Shifts that cannot be assigned within the constraints are flagged and can still be assigned after manual intervention through employee outsourcing or overtime.

Conclusion

In this report, we have tried to provide a frame of reference for the rise of AI for workforce management by introducing our experiences in three application areas.

We have also taken the opportunity to briefly discuss Solvice's differentiating factors: the processing of large volumes of data by our AI technology, the use of the most up-to-date academic knowledge and testing with real data. In describing the application areas, we emphasised how AI can improve the efficiency and robustness of the strategic capacity planning process, produce more accurate forecasts and allow for the improvement of employee productivity through autonomous scheduling.

This leads us to conclude that AI holds much promise for further streamlining workforce management processes and applications, despite the fact that an all-encompassing 'magic algorithm' or one-size-fits-all does not exist. As demonstrated in this document, this technology provides toolkits that can be used to activate an organisation's potential, reduce its cost base or develop a competitive advantage.

Solvice is leading the efforts to properly apply AI and develop new application areas by continuing to innovate in the complex world of workforce management.

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