ADEXA Predict, not just response

Using ML to predict manufacturing cycle times — Redundant and Not Accurate!

Many S&OP vendors are now using Machine Learning (ML) in order to estimate manufacturing cycle times. In this paper we argue that in the presence of an accurate model of the supply chain (a digital Twin), there is no need for this and it can actually be a misleading exercise. ML can be used for so much more and for areas where we lack mathematical and deterministic techniques to exactly figure out what the cycle times are.

More importantly we need to have the capability to influence and control cycle times depending on customer priorities, products and other factors.

Before we get into why ML is not a good tool for cycle time prediction, let's look at how ML works. It essentially looks at the examples in the past and remembers patters that create a certain value for the variable in question. In this case the cycle time.

For example, it takes into account the number of customers, number of orders, products etc. and tries to estimate what the cycle time would be for a particular customer or product. This is a silly way of doing it. Because what you have done in the past is not necessarily an optimal way of doing it in the future.

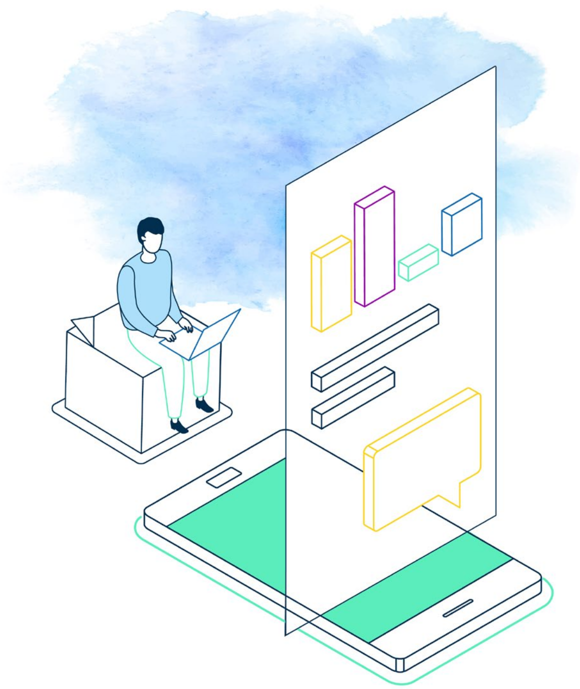
Using the same cycle times of the past does not improve your future cycle times. It merely reinforces poor practices of the past.

Furthermore, how would ML help you to change or lower your cycle times when there is a need for it? You may have the need to define a lower cycle times for certain customers and products and not so low for others? How do you constantly improve your cycle times if you keep imposing old practices and "learn" from it?

Moreover, if you are in an environment where your product mix is changing all the time then your ML algorithm may not even have enough data and examples of the past to be able to give you a reliable result.

Given all of the above shortcomings, why do most S&OP companies use this approach? It is simple, they do not have an accurate model of the factory or the supply chain (i.e. the digital twin).

They represent equipment with a bucket. This is not any different than a spreadsheet type of modeling. They assume you can do so many units per day or per week in that bucket. But we know that capacity for 100 units of product B may be enough for even 10 units of product C.



"S&OP Vendors do NOT have a true digital twin of the supply chain to properly represent the *look* and *behavior* of resources, factories, suppliers, orders or the entire supply chain."

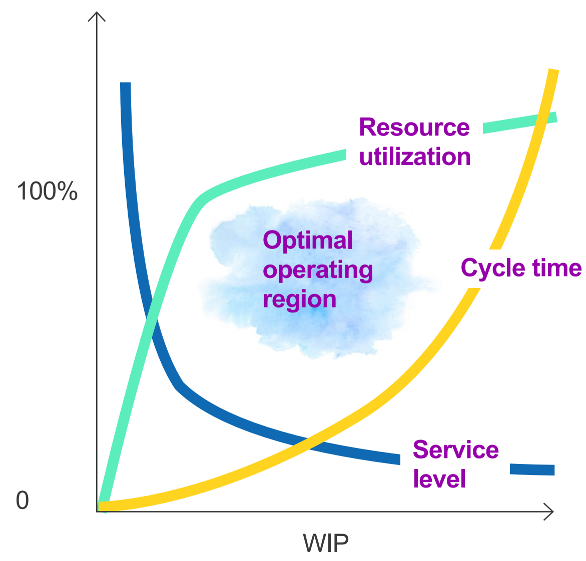
Now multiply this by hundreds, if not thousands, of products and try to use units per bucket as a measure of your capacity. Does this give you a reliable cycle time? Of course not. So, since they have a rough model of the supply chain at a high level, they try to guess the cycle times using machine learning. Not a good idea!

On the other hand, if the system can model the resources accurately including changeover times, processing times, setup times, operator skill levels, speed and capacity of each equipment for batching and parallel processing, then we can precisely predict the cycle time of each order in the future. *Cycle times are simply an outcome of the planning algorithm* that is trying to optimize the following factors.

Cycle times (minimize)

Resource Utilization (maximize)

Service Level (maximize)



Their relationship is shown in the diagram below. As you can see depending on the mix of products, as the WIP increase it contributes to higher utilization until all the bottleneck resources reach 100%. Beyond that there is no need to add WIP because it would only increase cycle times and hurt delivery performance.

The mathematical algorithms that we have developed based on queuing theory decides what is the best time to release orders or lots (i.e. the optimal WIP and mix of products) such that the three factors above are optimized. This is indicated in the diagram as the optimal region.

Adexa also enables the users to control to enforce certain lower and upper limits of cycle times depending on the product, customers, sub-routing and routing of each order or lot. The operating region can move left or right, up and down, by the users, for each customer or product to get the desired cycle time, service level and resource utilization.

In conclusion, having a precise and accurate model combined with optimization algorithms to determine and control cycle times in the future eliminate the need for the use of guess work or ML techniques just because a good model of the supply chain is missing.

Other Uses of AI/ML in Supply Chain Planning

At Adexa we have been using AI since 1998 for search strategies such as constraint propagation and Taboo search as well as expert system technology for adapting to the supply chain policies. These techniques fall in three categories of Self-Correcting (Models of Supply Chain), Self-Improving (policies) and Self-Optimizing (algorithms).

They are explained in detail **here**. A more related discussion to the above topic is self-correcting model of the supply chain so that the model is always up to date representing the true digital twin of the supply chain. Thus, as the physical supply chain changes so does the model by itself.

Examples are supplier lead times during different seasons, equipment efficiencies, and the likelihood of an equipment having a capacity between X and Y in the future.

For example, how confidently do we know that in the month of December the equipment availability of a certain bottleneck resource is 85% or more. Information like this helps the system to plan just the right amount of load on the equipment so that we are not being unrealistic as to what can be done.

Thus, avoiding over-promising to customers or under-utilizing expensive resources. Same kind of deductions can be made regarding setup times, availability of operators, impact of maintenance on equipment utilization, changes in supplier lead times from a certain region and many more.

As an example for self-improving policies, ML is used to decide on safety stocks for different types of inventory (raw, WIP and FG) depending on the region, season, customers, quantity and products so that just the right amount is maintained in order to deliver optimal service levels.

Please refer to **www.adexa.com** for extended discussions on Adexa Genies© and the distributed architecture that we have built to perform business processes autonomously.

Let's make **accurate** plans together!

"There are constant changes to the supply chain and its behavior. Some are not even noticeable until it is too late. ML can help to find these patterns to self-correct the digital twin and self-improve policies."

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