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# How Do You Build A Product That Has 10 Billion Variations?

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If you're anything like me, you look for a car that uniquely represents you. In fact, when I worked for General Motors, I

custom-configured the 1999 Pontiac Grand Prix GT that I proudly drove for the next 17 years. I could tell you exactly why I picked each of the features I had ordered. The prize feature? My heads-up display derived directly from that used in USAF jet fighters and built by Raytheon, then also owned by GM.

This story is nostalgic but also very relevant to the challenges facing manufacturers today. The recent computer chip shortage has resulted in a shortage of new and used cars on the market. Automotive manufacturers are using the few available chips to build the more expensive, high-profit margin variants.

Even though OEMs are producing fewer cars, the vehicles they do build have millions of possible part and feature combinations. And this complexity is causing havoc as the automotive companies try to judge demand six, three and one month out. They're trying to get their entire supply chain organized around their best guess at what will sell—unless, of course, Waymo orders 1,000 cars to turn into self-driving vehicles or Hertz orders 20,000 vehicles as business travel comes back.

But where did these incredible millions of build combinations come from? In 2020, Bentley began offering consumers “up to 10 billion possible product configurations per model.” We're talking about hundreds, if not thousands, of different product features.

And if you think Bentley is unique with its customization options, just look at Ford. If you customize your dream F-150 truck on the Ford website, you'll be choosing from eight models, three engines and six electronics options. And you'll be selecting many binary (yes/no) options like a running board and moonroof.



This will result in millions of build combinations—driven primarily by the 2^n multiplier due to the n binary options. If 2023 Q1 production numbers hold fast for the rest of the year, Ford will produce about 680,000 F150s. With this number of features, many trucks will be unique.

The mass customization challenge is one every manufacturer faces —from the much-maligned toilet paper manufacturer to Apple. So, how do these manufacturers execute in the face of these vast complexities? Most companies will:

1. Reduce the number of options, as Steve Jobs famously did when he rejoined Apple in 1996.

2. Create packages among the options they still choose to offer based on conjoint and segmentation analyses of previous orders.

3. Stabilize demand by securing many pre-committed orders.

4. Invest heavily in building automated, flexible factories.

5. Build and store as much inventory as they need to fulfill orders, which adds to the inventory and cost in the supply and distribution networks.

Unfortunately, as we've seen, even in the last few Covid-19 years, this likely won't be enough to meet production demand. Companies could be forced to build more factories. These capital expenditures could, in turn, force them to increase their unit sale volumes so that the expensive new plants don't sit idle.

But there's a solution that most companies tend to overlook—using math to create capacity.

When mathematicians looked at the planning and scheduling challenge at the core of managing supply and demand, they classified this long-standing manufacturing problem as NP-hard. NP-hard problems are essentially considered unsolvable because they require a prohibitive amount of computation time. So, the manufacturers simply gave up on trying to generate the perfect plan.

Instead of math, they relied primarily on tribal knowledge—the expertise and intuition that their senior planning and scheduling team members built over the years. They used—and in many cases, still use—simplistic tools like Excel spreadsheets for sorting based on a handful of top-priority constraints. Some have stepped up to heuristic scheduling solutions that are essentially Excel with a nice drag-and-drop experience and a graphical overlay.

But things have changed. The planning and scheduling problem has been largely solved thanks to an increase in and easy access to computing power (especially in the cloud) and a new class of AI and optimization algorithms that can generate near-optimal plans or schedules—often in real time.

Advanced planning and scheduling software (APS) solutions can generate significant improvements in schedule quality and integrate with existing production systems (e.g., ERP and MES systems). The potential benefits include increased production capacity, on-time delivery, growth in workstation and workforce utilization and reduced inventory, wastage and planning and scheduling time.

If you're trying to build goods and don't have the CAPEX to put more lines down, you could consider implementing modern APS software to help increase your use of existing production capabilities.

Here's how you can do it.

1. Select an APS system that's powered by constraint-based optimization technology, which aims "to find a consistent solution that optimizes some cost function."

2. Integrate the APS software with your existing MES, ERP and MRP production systems so the optimization process is an integral part of your business process. Major vendors like SAP and Oracle have many APIs available.

3. Model your manufacturing environment and production rules in the APS software using constraints. The richer your model, the more representative it will be of your business and the more optimal the result.

4. Run the APS software to generate your production plans and schedules. Modern APS software should run fast enough to enable you to (re-)plan in minutes, if not seconds.

5. Analyze your plans and schedules with the provided charts and dashboards to make sure you're achieving your production goals.

6. Iterate, if necessary, by exploring different scenarios and picking the one that best fits your business needs (e.g., being robust to a supply chain disruption).

Whereas uncertainty in business—such as customer preferences, material availability and logistics—creates constant headaches, the use of math can provide solace. The more manufacturers appreciate and use sophisticated math, the better off their businesses could be.

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