Supply chain planning will undergo fundamental change. The coalescence of technologies presents the opportunity to move from deterministic to resilient planning. Supply chain technology leaders responsible for supply chain solutions should explore this opportunity.

**Impact**
- The coalescence of emerging technological advancements is creating the opportunity for supply chains to move from a traditional deterministic planning mode to a full stochastic one. Gartner calls this new mode resilient planning.

**Recommendations**
Supply chain technology leaders responsible for supply chain solutions should:
- Change the supply chain planning (SCP) paradigm from deterministic to resilient by leveraging the combination of new technologies and a mindset change about how they perceive planning.
- Make more, faster and multiple predictions by leveraging cloud platforms for hyperscalability.
- Model and simulate the physical supply chain and align decision making across the supply chain by using a digital supply chain twin.
- Ensure the different planning decisions required by resilient planning are supported by deploying planning analytics in line with the CORE model.
- Drive from unknown uncertainty toward known variability by utilizing artificial intelligence (AI) and machine learning (ML) for better predictions.

**Analysis**
Are we heading for a perfect storm in SCP? Can we at last identify a real turning point for SCP? A point at which SCP can truly redefine and reinvent itself and become relevant for the present and
the future? Certainly from a technology perspective the perfect storm is getting close and it means that SCP technology leaders can at last start to reimagine planning for their company.

Today’s SCP lives in the past. This is a provocative statement, but many organizations can relate to this sentiment when they objectively analyze how successful they have (or have not) been in improving the performance of their supply chain through their planning capabilities over the last decade or so.

Planning is still based on a nearly 60-year-old paradigm that involves forecasting demand and then propagating this signal back up the supply chain. This paradigm was originally encapsulated in the material requirements planning (MRP) algorithm that first appeared in the early 1960s. The whole premise of this planning paradigm is to try to create an accurate plan for the supply chain which can then be executed. If there are accurate demand plans, bills of material, lead times and capacity levels, then the upstream supply plans can be accurately calculated and are executable. The hypothesis here, is that if there is an accurate plan then a factory, distribution center or even a supply chain can execute to this plan and thereby achieve the goals inherent in the original plan. However, there is a problem — uncertainty and the associated inaccuracy. As an old military saying goes “no plan survives first contact with the enemy.”

The enemy of accuracy-based planning is uncertainty. Uncertainty makes the plan inaccurate.

Back in the last half of the 20th century supply chains were simpler and given to more steady-state conditions — such as less uncertainty. There were fewer products and stocking locations. There were lower consumer expectations and longer decision-making cycles were permissible. These conditions are no longer relevant for any supply chain in the modern world. As every SCP leader knows, the world of supply chain is more complex and uncertain than ever before.

SCP technology has tried to respond to this increasing complexity and uncertainty. The evolution of SCP solutions utilizing optimization started in the 1990s. These solutions tried to apply advanced analytics to make the plans as feasible and accurate as possible. For a while they worked (to a degree), for those companies willing to invest the huge amounts of time and effort. Meanwhile, complexity and uncertainty continued to increase. SCP technology providers responded again by creating planning platforms with a single data model to enable better end-to-end collaboration and scenario capabilities. All designed to try to help organizations plan more complex supply chains by allowing decision makers (aka planners) to share the various scenarios with each other to hopefully improve the plan quality and circumvent the growing uncertainty. Today, these same vendors are busy adding ML to their SCP solutions to try to improve prediction quality for the likes of demand forecasting. Again the aim here is to try to improve the accuracy of the plan.

Through all this evolution in the technology and its application to SCP solutions, improvements have been made, but have been incremental. The issue is that the underlying planning paradigm hasn’t changed. It remains — “create an accurate forecast and then propagate this demand signal upstream through the supply chain.” In the early days of SCP solutions the planning approach was constrained by the technology itself. The SCP applications sat on slow, small capacity computers.
This restricted the level of detail the plans could be created at and/or the data used to create these plans, how often the plans could be refreshed, and how many versions of the plans could be produced. Plans were typically created at an aggregate level (e.g., SKU location rather than at customer SKU location level or even consumer level) and only refreshed periodically (originally monthly and even today most companies do not refresh their plans more frequently than daily). Most importantly today’s SCP solutions still only create one plan — a single plan for the supply chain. There is essentially one demand plan and one associated supply plan. Yes, the SCP solutions can create scenarios now, but how many? A couple? Three maybe? These scenarios are typically created in an ad hoc fashion when there is a big disruption of some sort on the demand or supply side.

Why is this a problem? Well it wouldn’t be if the plans created were 100% accurate and, therefore, 100% executable. But as anyone in planning knows plans are never accurate — that’s the problem. This problem is caused primarily by uncertainty — uncertainty of demand, uncertainty of supply, uncertainty of delivery, etc. Supply chain plans typically take little or no account of uncertainty. Some organizations try to protect their plan from uncertainty by adding in buffers such as safety stock — sometimes these are even sized based on forecast error or even lead-time variability. But the planning algorithms ignore these buffers — the planning paradigm dictates that these buffers are never planned to be used. They are there just in case execution goes off the plan between planning runs (during which new orders can be planned to compensate for these changes) and/or inside of replenishment lead times. In response to this, companies try to run their planning solutions more frequently — hence the new term “continuous planning” which is swirling around the SCP market now. This approach advocates that the planning algorithms can run whenever there is a change in execution (e.g., a new order or a change to an existing order). Sounds good, right? But as some companies are starting to discover, this leads to very nervous plans — everything can be changed whenever there is a slight change in execution. Although most companies want to be agile and responsive to their markets, they also recognize the need to balance this with some degree of stability through their operations. Otherwise, how are they going to be efficient?

What’s the answer to this dilemma? How can a company master uncertainty and still run its supply chain in an effective way? Gartner believes the answer to these questions lies in the rise of resilient planning. As shown in Figure 1, five forces combine to give birth to resilient planning. So what is resilient planning?

Resilient planning is defined as mid- and long-term plans that mitigate against uncertainty by ensuring the right degree of resiliency is built in so that short-term plans are more executable. A defining characteristic of resilient planning is that the short-term planning algorithm is not always end to end, but primarily considers only a single decoupling point to ensure the
built-in resiliency is fully leveraged to ensure execution is feasible.

Figure 1. Key Factors Driving Resilient Planning

To achieve this, resilient planning needs to appropriately separate the execution-level plans from the strategic and tactical-resilient-oriented plans through the use of buffers. There will be no end-to-end demand signal propagation at the execution-level plans. This ensures that the strategic decoupling buffers are used as intended. The tactical-level planning must evolve so that appropriate end-to-end analytics are deployed to figure out what kind, where and what size these strategic buffers need to be to allow the execution-level plans to be immune to uncertainty.

Resilient planning cannot arise from the traditional SCP approach or technology. It requires the five impacts of hyperscale cloud platforms, AI and/or ML, digital supply chain twins, the CORE model, and a planning paradigm shift to coalesce to create a new future for SCP (see Figure 2).
Impacts and Top Recommendations for Resilient Planning

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Source: Gartner (November 2019)
ID: 434210

Impacts and Recommendations

Change the Planning Paradigm From Deterministic to Resilient

SCP has been driven by a deterministic planning paradigm since the invention of MRP. If a company will derive the full business value from the new and emerging technologies, then it needs to change. It needs to embrace a mindset of resilient planning. If it doesn’t then it risks just applying the new technologies (such as AI and ML) to the old way of planning. This will bring some benefits no doubt, but the level of benefit will pale in insignificance when compared to a resilient planning approach.

In a world of high and increasing uncertainty the way the organization plans its supply chain needs to master this uncertainty through the way its supply chain plans are created and updated. Gartner expects to see companies that are leading the charge in digital planning (and are at the higher levels of digital planning maturity) to figure out that they need to change their planning paradigm to extract the most value from their new technology investments.

The utilization of the technology trends described below will enable a switch from deterministic to resilient planning.
**Recommendations:**

- Start the switch from deterministic planning to resilient planning by challenging the way planning is currently accomplished in the organization.
- Promote planning approaches that champion the use of new technologies to create plans that embrace uncertainty, and properly plan for it through the use of resiliency.

**Leverage Cloud Platforms for Hyperscalability to Make More, Faster and Multiple Predictions**

SCP solutions have been moving to the cloud for several years now. Sometimes these are vendor proprietary clouds, other times they are third-party clouds where the SCP solutions are hosted. Often the SCP vendors want their customers to move to their cloud option because it suits them, the vendor.

However, several incumbent SCP vendors and most new entrants to the SCP market are putting their planning solutions onto one of the large hyperscale cloud platforms such as Microsoft Azure, Amazon Web Services or Google Cloud Platform. These platforms are highly scalable, and with the appropriate design and architecture, the planning applications can take advantage of this scalability. This allows them to perform multiple calculations because of the speed advantage. Instead of creating a single plan for the supply chain, they can create tens or even hundreds of different plans; all assuming different starting conditions that give rise to different probabilities of an outcome. This approach of calculating multiple plans, drives the creation of probabilistic plans that speak to the level of risk associated with each of them. The market is already starting to see probabilistic forecasting and replenishment solutions — all of which are sitting on hyperscale cloud platforms.

A switch to resilient planning requires hyperscale platforms, due to the speed and number of plans that will need to be created.

**Recommendations:**

- Ensure the planning applications are fully elastic and highly scalable by deploying on a hyperscale cloud platform with the appropriate solution architecture.
- Ensure that any planning applications in your technology landscape are destined for a hyperscale cloud platform by examining the roadmaps for your incumbent SCP vendors.

**Deploy Planning Analytics in Line With the “CORE” Model to Ensure the Different Planning Decisions Required Are Supported**

For many years Gartner has been describing the key layers of planning via the “CORE” model (see “Getting Ready for the Digital Future: Strengthen Your Supply Chain Planning CORE”). As companies move to the next generation of planning capabilities the CORE model is as important as ever.

The CORE model describes the three planning layers of configure, optimize and respond planning. The “E” in CORE reminds us that planning needs to be connected to execution visibility.
Horizontally aligned decision making is ensured by having end-to-end respond, optimize and configure planning — supported by end-to-end execution visibility. This means that if an event or change is detected somewhere in the supply chain an appropriate response, or new plan, can be developed that keeps the supply chain in balance. Vertical alignment is ensured by having the right connections between these horizontal layers of “C,” “O” and “R” planning. For example, the decisions taken in the sales and operations planning (S&OP) process (enabled by the O planning layer) are aligned with those being taken in the sales and operations execution (S&OE) process (enabled by the R planning layer). This means that the trade-offs agreed in S&OP can be executed.

But this sounds like the type of deterministic planning companies do today. What would be different under resilient planning? The difference comes in the type of planning analytics that are used in the different layers of CORE. In a deterministic world these layers are focused on creating more accurate plans.

In a resilient planning world only the respond planning layer is focused on accuracy. It is the closest to execution and needs to be as accurate as possible to help support execution. The optimize and configure planning layers are focused on resiliency. They are further from execution and focused on longer time horizons. Their role is to build in enough resiliency to mitigate the uncertainty in the supply chain. With the right level of resiliency, the respond planning layer has enough “degrees of freedom” to absorb uncertainty so that execution is supported. Large number of plans and scenarios can be run in the C and O layers (as they will be sitting on hyperscale cloud platforms). This enables a better understanding of how uncertainty might impact the supply chain, and how best to compensate for this uncertainty in terms of how and where to build in the right level of resiliency. Think of it as running a designed experiment on the supply chain. Alternative analytical approaches such as discrete event simulation will be used in the C and O layers to test different supply chain plans and setups for resiliency. The results of the resilient plans will be parameterized (for example, buffer sizes) and sent to the R layer to tune how this layer will respond to execution events (and predicted events). This represents one of the key connections between the O and R layers in CORE.

Key to the R layer will be the ability to discern if an event can be resolved locally (say a single node in the supply chain) or needs to be resolved across multiple nodes. This is sometimes called the “ripple or waves” effect. Imagine if the supply chain is a pond of water. An event (large order, delayed shipment, hurricane, etc.) is analogous with someone throwing something into the pond. If a pebble is thrown in, then there will be small ripples that are local and can easily be “contained” locally. If someone throws a rock into the pond, then there are large waves lapping up all sides of the pond. These waves are now covering the whole surface of the pond. The respond planning layer needs to figure out if it was a pebble or a rock and decide on the appropriate response given the level of resiliency built in by the C and O layers. The R layer needs to be able to either make the decision locally (a single node) or end to end (multiple nodes), depending on the impact of the event. Ideally, the vast majority of R layer decisions will be made locally (so the planning algorithm is not propagating upstream) because a suitable level of resiliency is built in (via C and O layers) and can absorb the shock of the event. This then allows for far higher levels of decision automation in the R layer with only exceptions (i.e., rocks) being tossed up to the planners for collaborative resolution. This type of R layer capability allows for the continuous planning of the supply chain (monitoring for events and simulating their impacts) without the constant replanning of the supply chain.
chain every time something changes (the effect seen in deterministic planning). This allows a company to be agile and responsive to execution while dampening nervousness through the rest of the supply chain.

The degree of resiliency built into the C and O plans is akin to an insurance premium. The higher the level of noise and/or uncertainty there is, the higher this premium needs to be. Through the use of appropriate analytics (e.g., AI, ML or discrete-event simulation) a company can better understand uncertainty (what factors are correlated) and progressively incorporate that new understanding into its decision making. The result will be that it can pay a lower resiliency insurance premium and still be agile and responsive to the market.

A shift to resilient planning allows for these changes to planning but only if the planning analytics are in line with the CORE model, in that all layers are fully present in the technology landscape.

**Recommendations:**

- Audit existing SCP technology assets to better understand what coverage is currently in each of the CORE layers. Compare the current SCP technology landscape with key SCP initiatives (especially any digital planning requirements) and identify the gaps.

- Create a high-level SCP technology roadmap that highlights which CORE technologies are or will be required to support a future-state resilient planning capability.

- Link the evolution of the planning CORE to any digital planning goals by matching with the degree of horizontal and vertical decision-making alignment called for in your resilient planning roadmap.

- Ensure that the right links (e.g., data flows and simulation results) are established between the CORE layers by establishing a strong digital supply chain twin.

**Use a Digital Supply Chain Twin to Model and/or Simulate the Physical Supply Chain, and Align Decision Making Across the Supply Chain**

A digital twin is defined as a virtual representation of a real object. Digital twins are designed to optimize the operation of assets or business decisions about them, including improved maintenance, upgrades, repairs and operation of the actual object. Digital twins include the model, data, a one-to-one association to the object and the ability to monitor it.

The last couple of years have seen the evolution of what Gartner calls the digital supply chain twin. A digital supply chain twin is defined as:

A digital representation of the physical supply chain that remains synchronized with the physical supply chain when it changes due to internal and/or external events.
A digital supply chain twin is essential for any company that is looking to digitize its planning. This digital twin is the means through which the configure, optimize and respond planning layers are aligned. It is via the digital supply chain twin that predictive and prescriptive analytics (from the CORE layers) are applied across the supply chain. The digital twin is the means by which the implications of an event (e.g., Internet of Things [IoT] sensor signal, order change or predicted shipment delay) can be derived by playing this event through this digital representation of the physical supply chain to see what happens and what should subsequently happen.

In order to have integrated and aligned decision making across the supply chain it is important to minimize the number of models used — ideally to get to a single model. Then to make this a higher-definition model of the physical supply chain to enable higher-quality planning decisions.

When it comes to resilient planning the digital supply chain twin plays a crucial role. With this digital model of the physical supply chain, simulations can be made to see how resilient the proposed supply chain will be to variation and uncertainty. The optimize and configure predictive and prescriptive analytics can be run against the digital supply chain twin to test how well the supply chain will cope under different conditions. These resiliency tests will enable a company to identify the relevant buffers (types, positions, sizes) and planning regimes (e.g., postponement and decoupling, segmentation) that will determine the overall resiliency of the supply chain.

In a deterministic planning world scenario, what-ifs are created postevent. Once the event has happened (or is predicted to happened), a few scenarios can be run to help try to figure out what to do. In a resilient planning world, many of the scenarios and simulations will be run pre-event. Due to the presence of the digital supply chain twin and the predictions of future events, many scenarios can be created to help understand two things. First, how different supply chain configurations perform under uncertainty so that appropriate resiliency can be built in. Second, to have a catalog of prepared scenarios and/or plans that are available for when a specific event happens, or if the likelihood of it happening is strong. Once the probability of the event happening reaches a threshold, the appropriate scenario is automatically chosen and deployed.

The execution visibility layer of CORE keeps the digital supply chain twin in tune with the realities of the physical supply chain. The respond planning analytics will then be applied to the digital supply chain twin to predict and prescribe appropriate resolutions to the events impacting the supply chain. Due to the previous application of the optimize and configure planning analytics to the digital supply chain twin, tolerances and thresholds have been built in to allow the supply chain to absorb a predetermined level of uncertainty coming from execution.

As the digital supply chain twin is a digital mirror of the physical supply chain, the respond planning analytics create accurate decisions as to how to respond to the execution events (e.g., customer orders). With the digital supply chain twin representing the end-to-end supply chain, the respond planning analytics can accurately determine whether the decision can be made locally (e.g., at a single node in the supply chain) leveraging local resiliency, has to involve several nodes in the supply chain or the whole supply chain.
Through the existence of the digital supply chain twin the right level of resiliency can be determined to ensure an agile response to execution-level events such as customer orders, disruptions, shipment delays, weather events and new competitors.

**Recommendations:**

- Drive the SCP technology roadmap toward a single model of the supply chain. Multiple models damage the planning decision making and prevent “seeing” what level of resiliency is needed.
- As digital planning matures, drive up the resolution of the digital supply chain twin until it is a digital mirror of the multienterprise supply chain at Stage 5 maturity.
- Investigate whether your incumbent SCP vendors are planning to drive toward a digital supply chain twin. If they are, see if the resulting model is extensive enough (e.g., models your multienterprise supply chain) for your resilient planning needs.
- Examine the roadmaps of any supply chain visibility or control tower solutions being used, as these providers may be evolving their data model capabilities. Understand if the provider is considering building out a more extensive supply chain model that could be used as a digital supply chain twin. If so, consider this provider as a source of the digital supply chain twin.

**Utilize AI and/or ML for Better Predictions to Drive From Unknown Uncertainty Toward Known Variability**

The final piece of the resilient planning jigsaw is the application of AI and ML to planning decisions.

Most SCP vendors and many end users are striving to find use cases for AI and/or ML. In most cases these use cases try to create more accurate predictions (especially of demand) that can then be propagated back upstream. This does not change the planning paradigm. With AI and/or ML allied with the other impacts (hyperscale clouds, CORE and digital supply chain twin), the paradigm shift to resilient planning can be achieved.

ML is really a better prediction machine. It uses multiple data sources, and finds the patterns and correlations in that data to improve the accuracy of the prediction. This is why demand planning is the first area to get its attention. But it is still only a prediction — the accuracy is better, but not 100%.

What ML really helps with is its ability to convert unknown uncertainty to known variability.

This feature is important to resilient planning. One of the biggest issues for SCP is uncertainty — especially unknown uncertainty. The application of ML helps to convert this unknown uncertainty to known variability by identifying which factors are correlated to the target variable. For example, in a manufacturing environment the throughput on a key processing line is key to creating feasible production plans. However, this throughput is volatile and changes. With deterministic planning, an average throughput rate would be used to create supply plans. However, most of the time (due to
the uncertainty) the assumed throughput would be wrong. Therefore, either the company accepts under- or overproduction or, in order to “protect” the production plans, places significant buffers (capacity, inventory or both) to mitigate against this unknown uncertainty.

With ML, the relevant factors (such as processing temperature, raw material specification and/or pressure) can be correlated with throughput. Now the uncertainty of the throughput rate has been converted to known variability. The throughput rate will still vary (until the relevant factors are controlled more tightly) but the reasons for this variability are now known. The resulting production plans will be more realistic in that they more closely reflect the realities of the supply chain.

The large scale use of ML in SCP (supported by hyperscale cloud platforms) helps to quantify the uncertainty of the supply chain environment. This progressively changes the balance between unknown uncertainty and known variability. This enables the supply chain to be set up with the optimal level of resiliency to buffer this new level of uncertainty, while work can be undertaken to reduce known variability (e.g., better process control of pressure or better prediction of correlated factors such as weather, price, and/or competitive activity).

The combination of the ML predictions and the digital supply chain twin, enables the simulation of the supply chain to test the resiliency of its setup, leveraging the C and O planning layers of CORE. Over time, as uncertainty is converted to variability, and better managed and controlled, the amount of resiliency required for the supply chain to meet its goals can be reduced. The resulting “resiliency insurance premium” is lowered.

Once the supply chain is setup for resiliency, the respond planning layer can leverage this resiliency to ensure an accurate response to execution. Here, the use of ML is also important. As mentioned earlier, respond planning has to focus on accuracy. This requires better (more accurate) predictions in the short term. More accurate predictions of events such as customer orders, shipment delays, lead times, production yield. These more accurate predictions ensure that the respond planning layer can make the best decisions in the given circumstances. However, even with ML these predictions will not be 100% accurate. Leveraging the hyperscale cloud platform’s multiple predictions can be done to test for the likelihood of different outcomes, enabling the respond planning layer to decide what the optimal response could be to satisfy execution. By applying the respond planning layer to the digital supply chain twin (which incorporates the design level of resiliency) the response can be tailored to best leverage the available resiliency (e.g., inventory, time, capacity) at individual nodes or multiple nodes in the supply chain. This approach ensures the best possible response for the company to the execution event.

The use of ML in conjunction with the other technologies above ensures that an effective resilient planning approach can be developed.

**Recommendations:**

- Convert unknown uncertainty to known variability by focusing ML use cases appropriately.
Increase the resolution and quality of the digital supply chain twin by targeting the use of ML to correlate factors that drive variability in different parameters such as lead times, yields, throughputs and demand.

Improve the accuracy of short-term predictions in the respond planning layer by applying ML to better predict execution events (e.g., customer orders or shipments). Create multiple predictions to test for the most likely and best response (e.g., probabilistic forecasting and probabilistic replenishment).

Gartner Recommended Reading

*Some documents may not be available as part of your current Gartner subscription.*

“Supply Chain Brief: Digital Planning Requires a Digital Supply Chain Twin”

“Getting Ready for the Digital Future: Strengthen Your Supply Chain Planning CORE”

“Digital Business Requires Algorithmic Supply Chain Planning”

“Defining Digital Supply Chain Planning”

“Leverage Gartner’s Digital Supply Chain Planning Maturity Model to Improve Planning Quality”

“Hype Cycle for Supply Chain Planning Technologies, 2019”
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