# WHY RESILIENT DESIGN IS CRITICAL TO FIXING OUR SUPPLY CHAINS AND ENDING DISRUPTION

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## Executive Summary

- There is a perception that supply chain disruption is solely driven by "Black Swan" events like Covid and the Ukraine war. However, this is not the case. Operational disruption is endemic and is driven by the way supply chains are designed and planned.
- Supply Chains are highly variable complex networks of interconnected functions and organizational units that are dependent on planning systems to orchestrate the multitude of activities upon which the servicing of end customer demand is dependent. However, these systems have two major flaws: Firstly, they ignore inherent variability in their planning methodology. Secondly the design and configuration of these systems is manual and dependent on human operators to model the complex networks they serve.
- This planning conundrum drives operational disruption resulting in service failures, costs, inventory imbalances and waste.
- The supply chain of the future will utilize AI to automate the design of planning systems utilizing simulation to model variability and identify resilient networks that can respond in a cost efficient and agile way to risk and disruption.

## I. Introduction

It's tempting to believe that before the recent succession of seismic geopolitical shocks such as Brexit, Covid, and the Ukraine war that supply chains ran smoothly, and disruption was the exception rather than the norm.

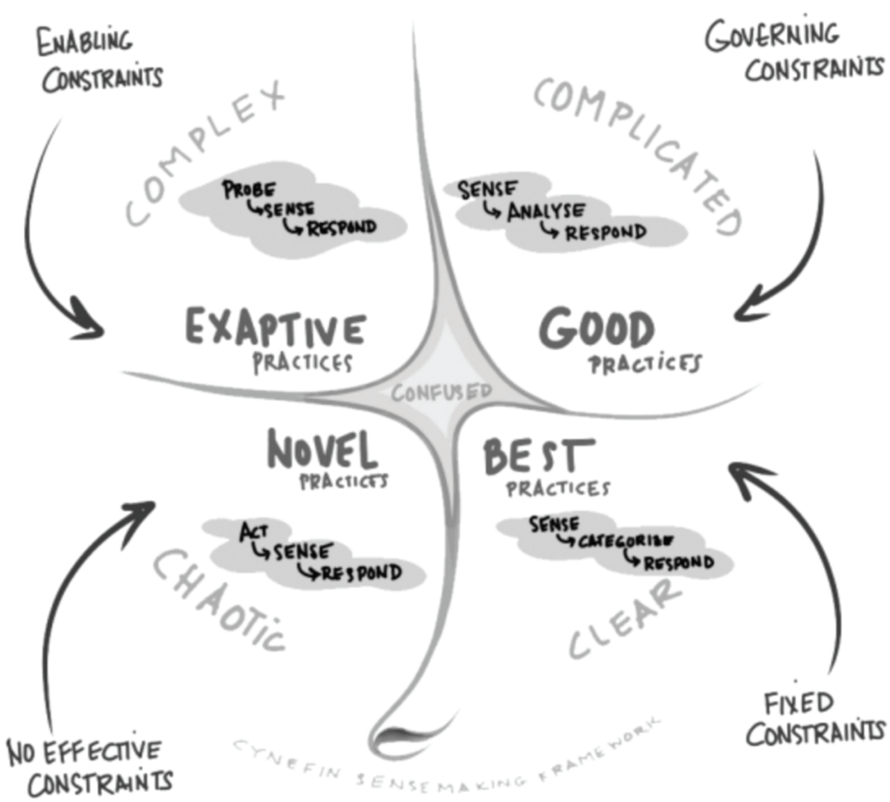
But this was not the case. Supply Chain disruption has become front-page news not because disruption is new, but because the scale of the disruption is bigger and the impact more visible. However, disruption has long been an inherent feature of Supply Chain Management; a discipline that has failed to move with the times and in 2022 is dependent on systems and paradigms that are no longer fit for purpose.

While the recent events are primarily 'Black Swans' that are seldom, if ever, to be repeated, they have exposed how the rigidity and frailty of our supply chains makes them vulnerable to large and sudden changes. What is lost in the rapid adjustment to these Black Swan events is that the frailty and rigidity are endemic and cause a great deal of friction even under normal operating conditions. Essentially, our supply chains are assumed to operate in the 'clear' or 'simple' quadrant of the Cynefin Framework below, and our processes and technologies are designed and implemented on these assumptions. Furthermore, it is assumed that constraints are fixed, and process conformance is valued more than process effectiveness. A key indicator of this is the universal dependence of supply plans on a one-number forecast.

The reality is that every supply chain is a highly variable and complex system requiring processes and systems that can probe for risk and opportunity through modification of enabling constraints such as service levels, inventory levels, shift patterns/capacity levels, and margin. Setting these enabling constraints is the remit of Supply Chain Strategists and consequent supply chain design should be intended to achieve these strategies. Both the optimization of operating parameters for existing supply chain infrastructure as well as the assessment of green field situations are important parts of supply chain design.

At the very least, Supply Chains are complicated networks in which demand and supply are changing constantly because of their inherent variability, and the supply chain must adhere to the governing constraints of performance targets.  Performing the demand/supply balance while satisfying governing constraints is usually the focus of IBP/S&OP processes which seek to model potential upside and downside opportunities and risk and provide structure for business-based decision making around these bands, still these processes do not address the issue of variability explicitly because none of the planning tools model variability.

### Grahpic 1: The Cynefin Framework



Black Swan events fall into the Chaotic quadrant, where survival is the name of the game. Black Swans test the full spectrum of supply chain management starting with design. The very worst response to a Black Swan is to use supply chain designs of both physical and informational flows defined for times of stability where cost effectiveness is the primary focus. This leads to the very centre of the Cynefin Framework where confusion reigns.

Gartner refers to the ability to understand and incorporate variability in all levels of supply chain planning, from design through to execution, as *resilience*. Interestingly, resilience requires both a constant re-evaluation of the supply chain design to incorporate the most recent performance figures and market dynamics, and the use of the adjusted design in the operational planning phase of demand/supply balancing.

# II. The Planning Conundrum

In this paper we will look at how the current planning paradigm and the planning systems that underpin it are responsible for causing disruption. We will explore the relationship between the planning system and how this is configured or designed and how this is in turn determines how the supply chain network performs and its resilience to variability and risk. In doing this, we will focus heavily on two major shortcomings of the current model. Firstly, its inability to cope with inherent variability in the way that plans are generated, and secondly, the fact that current systems and processes are reliant on human beings to manually configure or design them. These interrelated factors are producing operational disruption because they generate plans that are unable to cope with inherent variability and are driving operations that are reactive. This subject was explored in a previous Wilson paper by Julie Mendoza (https://www.wilsoncenter.org/event/can-technology-solve-trust-challenge-americas-supply-chains) The limitations in the current model results in disruption, costs, bloated inventories, and service failures that propagate and amplify across complex multi-national supply chain networks.

**Resilience requires both a constant re-evaluation of the supply chain design to incorporate the most recent performance figures and market dynamics**

We are cognizant that the design and performance of the planning system isn't the only factor driving the type of disruption we are seeing. Other factors such as the move to globalisation in supply chains, which has driven greater complexity, the profusion of disparate and multi-national supply streams, longer lead times and poor upstream visibility have all made networks more vulnerable  (see https://www.wilsonquarterly.com/quarterly/as-strong-as-our-weakest-link/the-new-values-of-supply-chain-thinking) These structural weaknesses have come under particular strain and been highlighted during this current period of geo-political disruption. However, addressing and potentially reversing these trends is a strategic exercise and will take time to change.

The issues with planning systems while also structural, given the way these systems are designed, built, and operated, can be addressed faster with modern automation. New technologies such as AI are beginning to present the opportunity to deliver an agile response by providing a stochastic approach to the design of resilient parameter configuration. We will look at how automating supply chain design using AI, advanced scientific modeling and smart simulation differs from the current paradigm and its potential impact on supply chain performance. One of the features of the last 48 months has been a greater focus at C-Suite level and with Governmental policymakers of the importance of supply chains. How this function determines the flow of goods and impacts their cost has become clearer.

Supply chain disruption impacts the bottom line of the business. A recent 2021 survey (https://www.statista.com/statistics/1259125/cost-supply-chain-disruption-country/) found that disruption is an economic hardship estimated to cost individual organizations around the world an average of 184 million U.S. dollars per year. This financial burden is highest in the United States, where the estimated average annual cost to respondents' organizations amounted to 228 million U.S. dollars. Extrapolating this cost shows the scale of the issue. The cost of supply chains that cannot manage variability is impacting consumers and the wider economy substantially.

The need for resilient, cost-effective supply chains for business survival and economic prosperity has never been more important or held as much focus. It is clear is that new solutions are needed. The basic supply chain management model remains unchanged over nearly 40 years. It's a model predicated on a number of wholly unrealistic goals and driven by systems that use outdated math and are unnecessarily dominated by manual processes.

Existing supply chain planning solutions are dependent on stable demand and supply and the capability of a human being to manually configure them. All of the Supply chain planning solutions that are currently on the market are deterministic. They work based on one single representation of future demand, one single representation of network capacity performance, lead times et cetera, and that single simulation is driven by the policies and parameter settings.

All planning systems are a simulation of the future. Existing systems generate a single simulation. This means that the systems have no way of representing inherent network variability in both demand and supply.

They are essentially a one-shot representation of the future. In this regard, they are dependent on an accurate prediction of the future.  When the supply chain environment is static such systems work effectively: They work where constraints are fixed, and process conformance is valued more than process effectiveness.

**Variability in demand means that while it is possible to determine a range of demand and probabilities around that range, pinpointing precise sales even on regular items in the portfolio isn't possible.**

If you can forecast demand accurately, you can model and predict future network variability, and you have configured your complex end-to-end planning infrastructure correctly, then the plans that determine how the network performs will be reliable. In this ideal scenario, things will be made when they should be and stocks will be held in the right quantities and in the right locations. Costs will be maintained at an appropriate level to balance service and maximise margins, and waste will be avoided.

In practise this is an unrealistic expectation. Forecasts are by their nature wrong to a lesser or greater degree. Variability in demand means that while it is possible to determine a range of demand and probabilities around that range, pinpointing precise sales even on regular items in the portfolio isn't possible. Networks are by nature inherently unreliable and often unpredictable. This unpredictability has been amplified by recent events. But like forecast accuracy, it has always been a constant feature of supply chains. Variability in supply is always there. Determining the level of variability and the most cost-effective network design to manage that variability for each item supplied is what needs to be built into our plans.

This is perhaps the most egregious shortcoming of existing planning systems: They all ignore the inherent variability in the supply chain. Planning systems have access to the data that exhibits this demand and supply side variability. So, it might be expected that these systems would have the capability to model the most appropriate parameter configuration automatically. However, that is not the case. In 2022 even the most advanced planning systems require manual design and are driven by operating processes that algorithmically and mathematically haven't changed since the 1980s. Planning Systems are completely dependent on human beings being able to accurately predict the future for them to work.

Gartner is beginning to discuss the need for 'stochastic' planning, which means the development and deployment of systems that both understand the variability and take the variability into consideration when generating a plan (https://www.gartner.com/en/documents/1804515).  Existing planning systems do neither.

Planning systems play a central role in determining how the supply chain network performs and its resilience to variability and risk. The planning system is the central nervous system of the supply chain. It's there to orchestrate the multitude of interconnected functions, organizations and processes that make up the extended end-to-end supply chain organization. The design of the planning system, or put more specifically, the configuration of the policies and parameters that determine how it plans, directly determines whether the supply chain functions in an optimal or suboptimal way. The design of these planning policies and parameters ultimately determines resilience.

When we talk about design, we are not focussed on the type of strategic network design that determines the geographical structure of networks, the location of facilities, and the type of capabilities in the supply chain network. These design features, while not totally fixed, are not dynamic and are often determined by strategic and often, organization-wide, considerations. Rather, we are focussed on the planning parameters and policies that need to plan for the dynamic aspects of the network. Those design features that determine how the supply chain planning systems and processes perform and which are critical in enabling the network to manage day-to-day variability. These factors determine how sales demand is met, what is made and when, what stocks are held, and where they are held. They directly determine how effective the network is in orchestrating myriad day-to-day activities to meet customers' needs and the cost of achieving that state for every item supplied by the business. They are the foundation of how supply chains operate and are critical to how those supply chains impact individual business viability and macro-economic performance.

# III. The Impact of the Planning Conundrum

It's worth emphasizing at this point the specific impacts that result when a system generates a plan which is incorrect due to poor design. It cannot be overstated just how damaging this is to the supply chain operation, the organization, and the wider macro-economic environment. It negatively impacts every organizational metric.

Where the planning system fails to adequately manage variability and instead expects that a one-shot plan is the best approach to coordinating the network, the planning system propagates disruption. The planning system drives every activity that translates raw materials to finished goods. In this era of globalization and multinational supply chains, these activities and processes are inextricably interdependent. Issues and costs in one part of the supply chain impact other network partners inside and outside of any one organization, and disruption in one part of the network has a knock-on effect across the entire chain. Every activity that is needed to successfully meet customer demand is impacted when plans are wrong, including production plans, component and intermediate product requirements, delivery scheduling, et cetera. All of these activities are driven by the planning system, and when plans are wrong it has an exponential impact on service, costs, inventory, waste and sustainability/carbon. These costs either drive reduced margins and profitability or are passed on to B2B partners or the end consumer. Likewise, delays and disruption are proliferated, driving the chaos in networks that we see making the headlines.

Disruption is the norm because the planning paradigm doesn't deal with variability. Supply chains are dependent on intervention (for example, freight expedites and manufacturing interruptions) because resilience to variability is not designed into the planning parameters that drive the planning process. In terms of Policies or Planning Parameters, we are referring to broadly two types of parameters. Firstly, replenishment policies, which regulate how the plan determines what should be made and what stocks buffers are needed, in other words, where to hold stock and how much to hold. Secondly, we are talking

about policies such as lead times, transport times and quality testing times, factors that are key to determining when things should happen. In determining these policies and parameters, dynamic network variability needs to be measured and the balance between service and cost modelled.

For example, setting stock levels or buffers needs to consider demand variability, lead time variability, replenishment frequency and associated costs, all of which is a highly complex modeling task. Get it wrong and you end up with too much or too little stock, service issues and/or waste.

These critical policies are currently set manually, often by inexperienced or unqualified planners, and in most cases, they are reviewed infrequently. The planning system doesn't calculate them nor does the ERP system (which is often where they are held and maintained). It's down to a human to model them. All of these policies are interrelated aspects of the supply chain design and need to be under constant review based upon the actual performance of the network, which is itself dynamic.

Reacting to the impacts caused by this disconnect is the prevailing paradigm in many organizations with planners frequently acting as firefighters; expediting, rescheduling, and intervening to manage issues intrinsic to the model. In summary, we have the following happening in our supply chains:

- Planning systems that are a single simulation of the future and that don't take account of variability
- A model that has no way of reflecting probabilistic outcomes and likelihood in the plans they generate
- Systems that are manually configured and infrequently updated despite the dynamic nature of the networks they plan
- Significant gaps between actual network performance and policy settings
- Service failures whose impacts spread across networks and organizations, cause excessive costs, and bloated inventories, and result in widespread waste in both material and human effort

- The impact that disruption and costs are being propagated exponentially across extended supply chain networks, impacting in turn the performance of businesses, and in turn impacting availability of goods to consumers and the costs of those goods.

## IV. Resilient by Design: A New Paradigm.

Supply chain organizations must rewire themselves to be better placed to manage variability. This requires automation of supply chain design, and it requires greater visibility and resilience to risk being built into how supply chain networks are configured. There is a golden opportunity to build resilience through improved modeling and application of new technologies such as AI and Machine Learning.

As digitization provides greater scope for understanding underlying network variability, it is key that systems adapt to be able to use that data to understand and model strategies to automate this complex supply chain network design task.

One company that does this is Oii.ai, a San Francisco based start-up that has developed a cognitive modeling solution, Optii, that automates network design. Oii.ai removes the dependence on a human having the capability to accurately predict the future by applying a new probabilistic approach to the management of supply chain design.

The AI doesn't replace the planning set up. Rather it augments it. The Software enables dynamic simulation of underlying network variability and the identification of resilient strategies to maximise customer response across a range of dimensions such as profitability, waste, inventory holding, and cash flow. Rather than generating one single simulation of the future as existing systems do, AI enables us to run multiple simulations of how future network performance might play out, taking account of multiple profiles of variability and multiple potential policy or parameter settings.

Oii's system plugs into the existing planning infrastructure and builds a digital twin of the supply chain. It then leverages AI and Smart Simulations to create a stochastic prediction of the challenges that the supply chain must be prepared for and then computes the optimal network configuration to meet business goals.

This enables the software to first simulate how the current supply chain set up actually behaves, determining current resilience, cost and risks of service failure. Next, by looking at all the other ways the supply chain could be set up and recording the performance of each of these under the same predicted future conditions (demand, network performance, and supplier variability it determines the optimal way to configure the network.

It's not a single simulation like a planning tool, but applies multiple simulations drawn from a multiverse of digital twins, all modeling different profiles of demand and supply variability. All of these constantly changing inherently variable dynamic factors are continually calculated and different options simulated to make sure that the network is maintained at an optimal level, that resilience is continually built-in, and that costs are optimised.  In this way, the tool designs and maintains network parameters and policies that are cost effective and resilient to variation.

Oii.ai has tracked the impact it has had over a number of deployments and the following benefits are typically delivered through its automation of resilient supply chain design:

- 30% Inventory Reduction
- 10% Reduction in Service Risk
- 25% Cost to Serve Reduction
- 50% Reduction in Discards/ Waste
- 20% Reduction in Factory Complexity

# V. Conclusion

Supply chain disruption is a contagion that costs organizations billions, undermines economic performance, and in the worst cases leads to empty shelves in our stores. While major events such as Covid, the Ukraine war, and other "Black Swan" events have highlighted the issue of supply chain disruption and its costs, these are not the only drivers of supply chain disruption. A major cause of supply chain disruption is the current planning paradigm, which doesn't manage inherent variability and is reliant on manual network configuration and design.

The supply chain of tomorrow will be characterised by higher product flow, better customer service and lower overall supply chain cost. It's critical that greater automation of complex modeling be a key part of that supply chain landscape. As digitisation enables greater visibility of supply chain performance it's critical that we use actual measurements and data to build supply chains that are more resilient to variability and more cost effective in how they support organizations and the wider economy. Designing how networks are planned can no longer be a manual task. Supply chain design must support the modeling of more cost-effective pro-active resilient networks. Resilience by design is how our supply chains should be configured and automation is key if we are to achieve that critical objective.

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