The Impact of Structure on Supply Chain Performance and Resilience: The Reciprocal Bullwhip Effect

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In a previous white paper (**The Impact of Structure on Supply Chain Performance and Resilience)**, the impact of the structure of a supply chain on its performance was discussed. Using a scientific experiment approach holding all variables equal across all entities in a supply chain, it was demonstrated that an OEM experiences different magnitudes and durations of disruptions based on whether or not the underlying supply chain is "narrow and deep" (e.g., three suppliers cascading through Tier 1, Tier 2, and Tier 3) or "wide and shallow" (e.g., three suppliers all as Tier 1).

Although not explored in the previous white paper, a common phenomenon well-known within the supply chain management field is the bullwhip effect. With the bullwhip effect, each successive tier in a supply chain experiences oscillations in orders and inventories that amplify and grow larger from the top of the supply chain to the bottom, with the lowest tier supplier experiencing the worst oscillations.

In this white paper, we explore the concept of the "reciprocal bullwhip effect." In this example, two OEMs share the same Tier 1 supplier (Figure 1). As in the previous white paper, a step-bump in demand at an OEM initiates changes with the supply chain. In the previous white paper, the OEM is the only OEM in the supply chain and the supply chain is solely dedicated to the OEM. However, in this white paper, two supply chains interconnect.

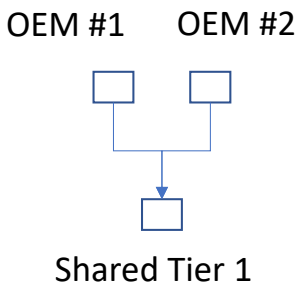

Figure 1: Two OEMs share the same Tier 1 supplier.

Figures 2 and 3 show the results for OEM #1 and OEM #2, respectively, to a bump in customer demand to OEM #1. For OEM #1, customer demand is constant prior to the bump in demand (hence, the straight lines for the first 10 weeks on the graphs) and remains constant after the bump. Thus, any fluctuations seen in the graphs are the results of how the various entities react to orders changing throughout the supply chain as each entity attempts to regain its balance of inventories and production rates.

Figure 2 shows the results for OEM #1. Starting after week 10, the chart shows the fluctuations in receipt of raw materials from the OEM's suppliers, raw material, production rates, finished goods inventory, and deliveries to the OEM customer. It is not important to know the exact values for this example. What matters are the relative differences seen in the fluctuations, which can be considered measures of disruption and resiliency for a supply chain. We could look at all the variables, but let us just focus on raw material inventory levels (blue line at the top of the graph marked with the number 2) to keep it simple. In Figure 2 for OEM #1, notice that the raw material inventory dips at first due to the

extra demand draining the raw material before the Tier 1 supplier has the chance to provide additional raw material. Then, the raw material rises to a level higher than the bump in demand as excess raw materials flow in from the Tier 1 supplier, and, finally, the raw material inventory settles to a level that is commensurate with the new higher demand and stays constant after that.

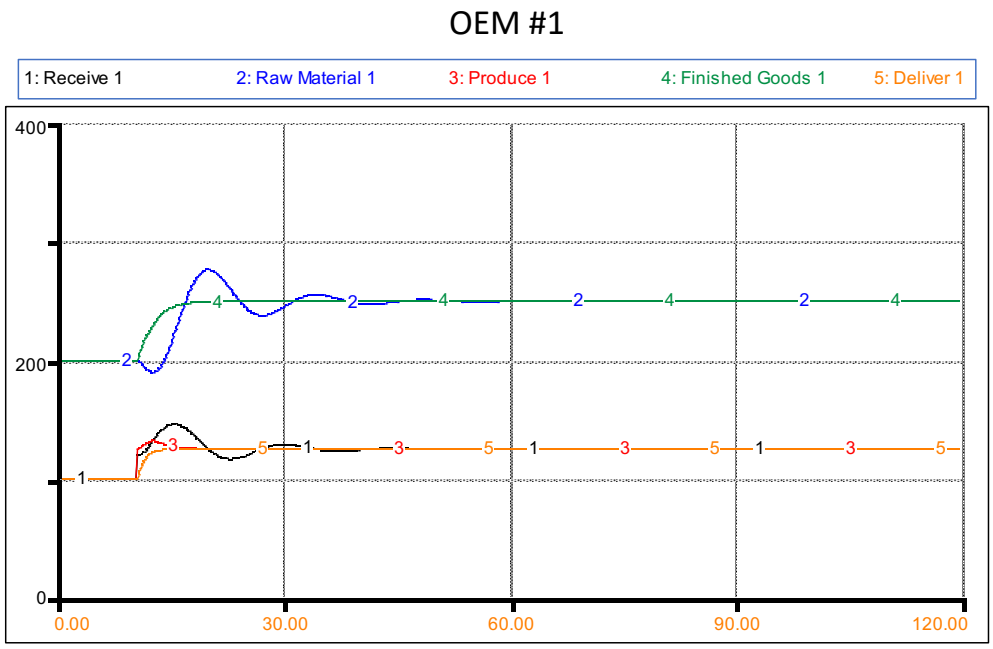

Figure 2: OEM #1 bumps orders by 20% and experiences fluctuations in inventories, etc.

Figure 3 shows the results for OEM #2. Similar to Figure 2 for OEM #1, starting after week 10, the chart in Figure 3 shows the fluctuations in receipt of raw materials, raw material, production rates, finished goods inventory, and deliveries at OEM #2. Again, just focusing on the raw material inventory levels (blue line at the top of the graph marked with the number 2) to keep it simple, notice that the raw material inventory in Figure 3 exhibits oscillations, yet there has been no change in demand at OEM #2. The oscillations experienced at OEM #2 are the result of delivery delays from the Tier 1 supplier as it adjusts its production capacity to meet the new higher level of demand from OEM #1. For a period of time, the Tier 1 supplier struggles to meet all combined demands from both OEMs, which kicks off the oscillations. Eventually, everything settles down and there is stability at the new elevated demand level. Thus, even though OEM #2 would often be considered a "separate" supply chain from OEM #1 that operates independently from OEM #1, OEM #2 is impacted by activities from the "other" side.

In a broader sense, this means that any supply network in which there are overlaps of lower tier suppliers can suffer from ripples and oscillations traveling UP, DOWN, and SIDEWAYS in the network. No entity is isolated from the activities of other entities in the supply chain. An entity can be impacted by changes at its direct competitors. An entity can be impacted by changes at lower tier suppliers that are not even part of its supply chain if those lower tier suppliers share an upper tier supplier.

OEM #2

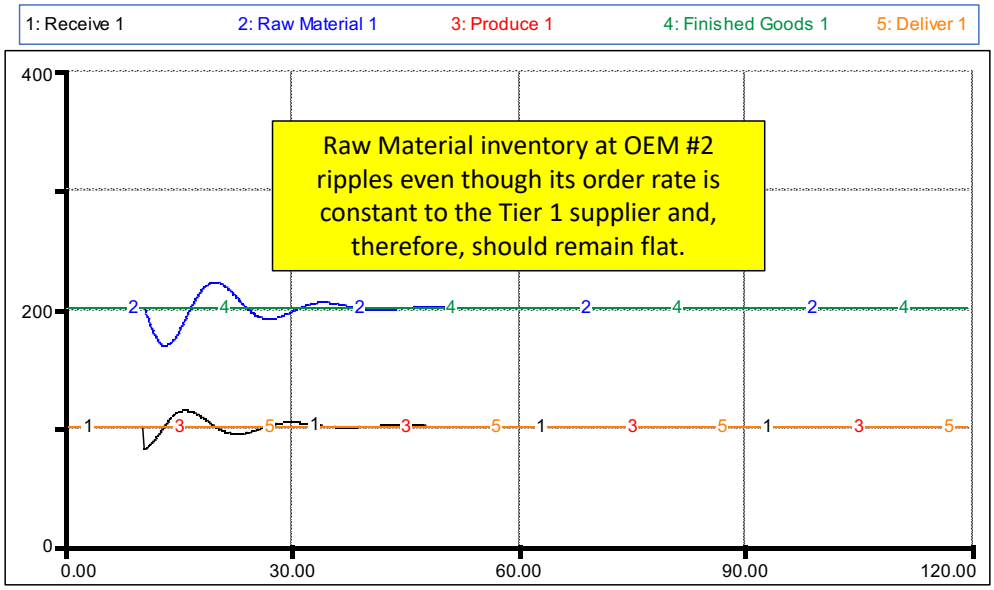

Figure 3: OEM #2 maintains steady orders but still experiences fluctuations in inventories, etc. due to changes in demand from OEM #1 flowing through their shared Tier 1 supplier.