

The Bullwhip Effect



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Hans Ehm Supply Chain Innovation



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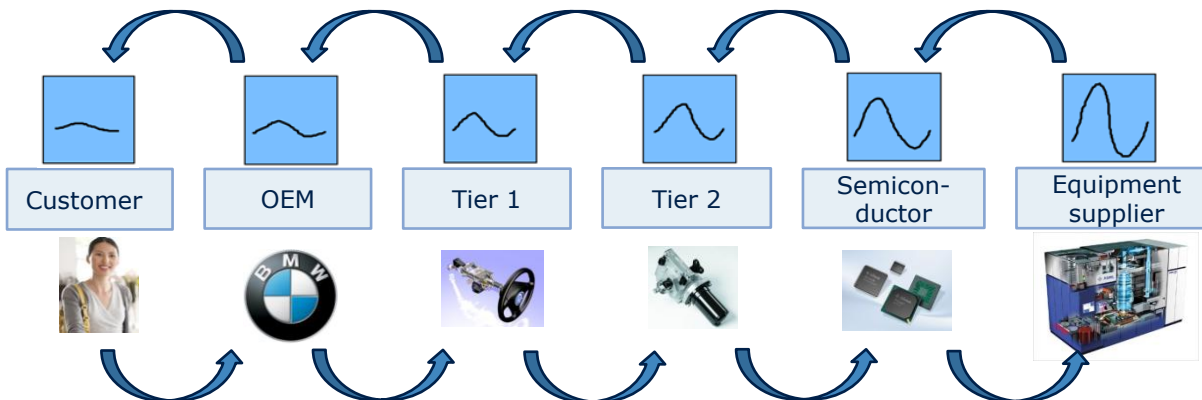
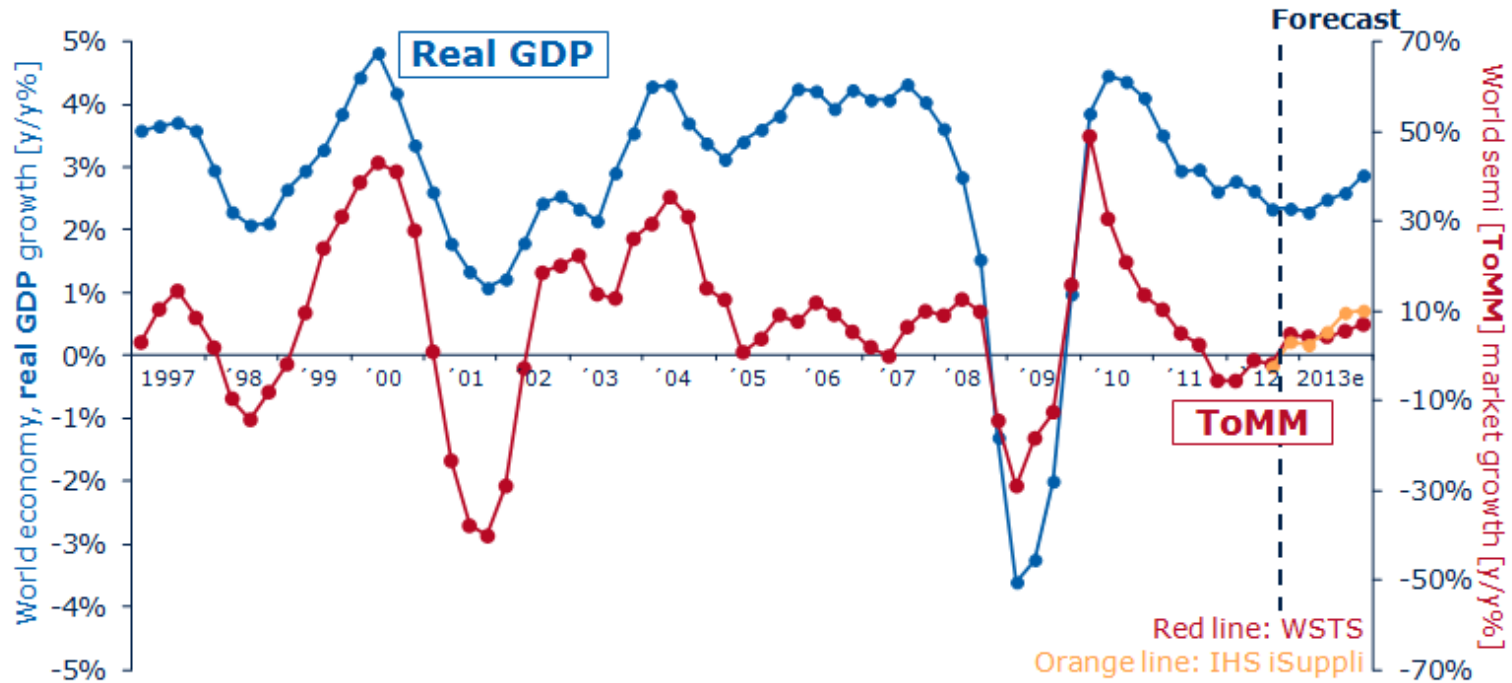
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Risk comes from the nonaligned supply chains - the bullwhip effect



Bullwhip Effect
Overshooting in the value chain

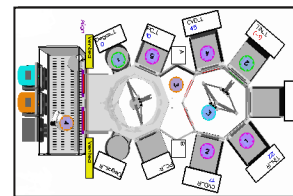
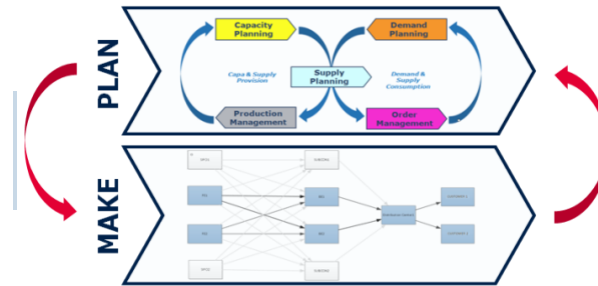
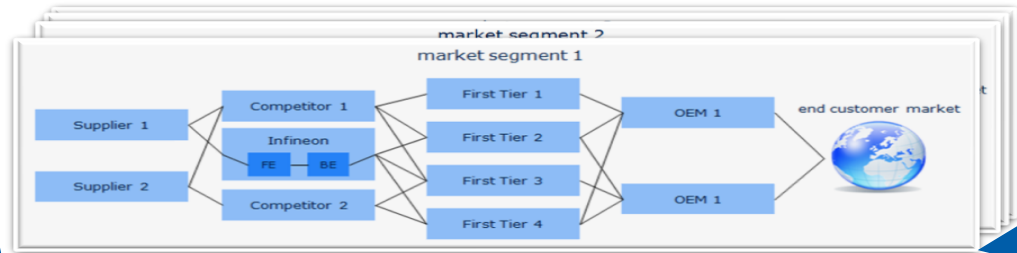
Semiconductor Supply Chain - Model Hierarchy; Level 4 Challenge: Bullwhip

■ Level 4:
End-To-End SC

■ Level 3:
Company SC

■ Level 2:
Production Site

■ Level 1:
Cluster/Equipment



The Challenge - (Why?)

- The bullwhip effect is a well known and studied phenomena of human behavior that effects supply chains in all industries.
- It posits that there are larger and larger fluctuations in demand the further back you look in a forecast-driven supply chain.
- It is, however, even more important to understand its drivers and impacts in the semiconductor industry, as the long cycle times, high capital costs, and rapid price decline (Moore's Law) put extreme pressure on supply chains to be as lean and efficient as possible.

The Goal - (What?)

- In order to test the AnyLogic[®] modeling software package, we wanted to model a well-known and researched, yet ever important topic within the field of semiconductor manufacturing.
- We wanted to show what the bullwhip effect looks like in our supply chain and to what extremes it exists.
- We also wanted to examine the connection between market demand fluctuation and the fluctuation in demand we receive from our direct customers.

The Idea – (How?)

- We created agents for each of the major players in the supply chain and gave them behavior based on the well known “Beer Game”.
- We then retrieved real GDP and Semiconductor market data to use as our input signal.
- Finally, we re-created a simplified internal structure for Infineon. The agents, Infineon, and the market were then all linked together using discrete event process simulation methods to combine a hybrid model with a highly realistic structure

Lean Modeling Approach

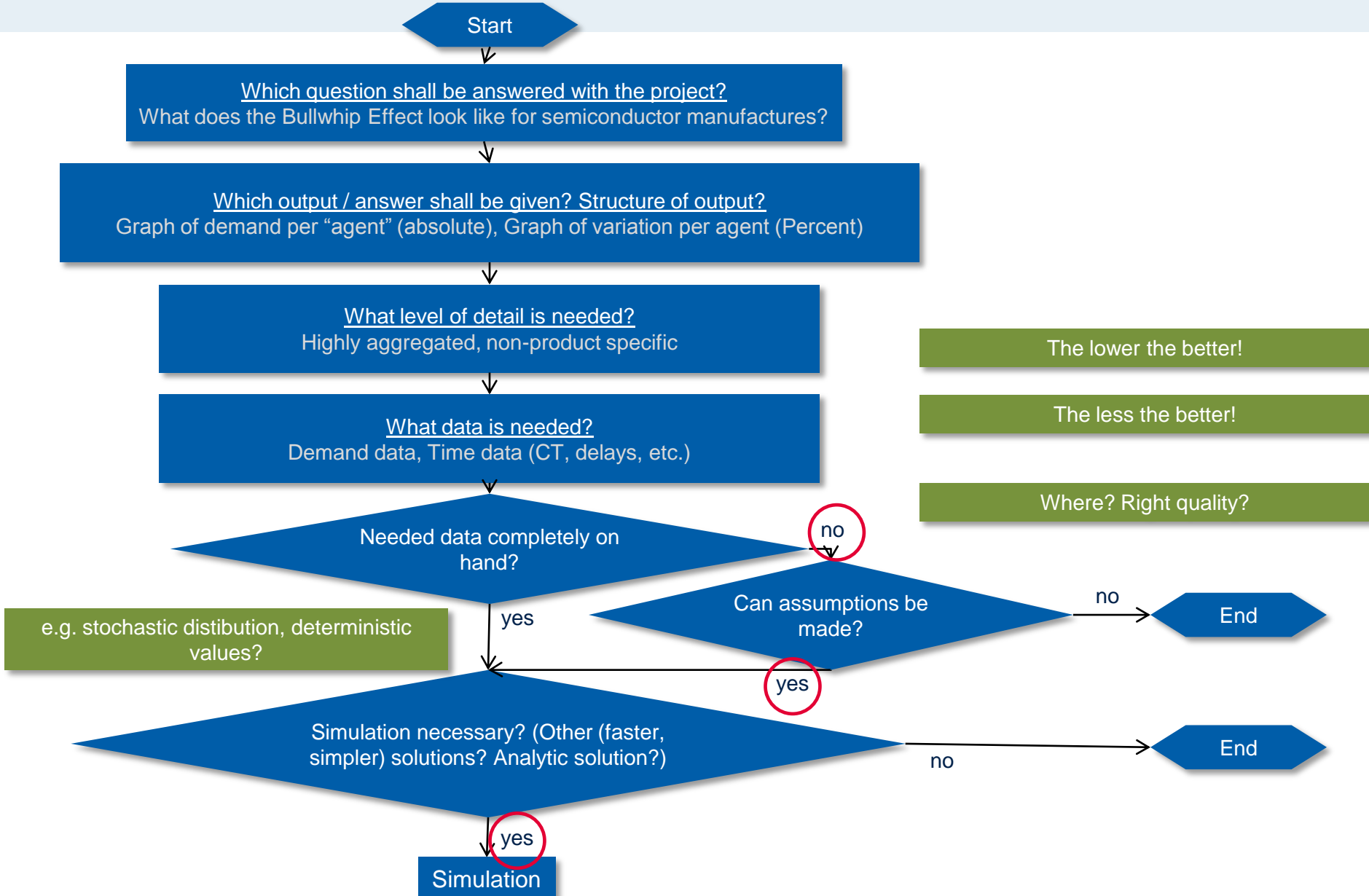


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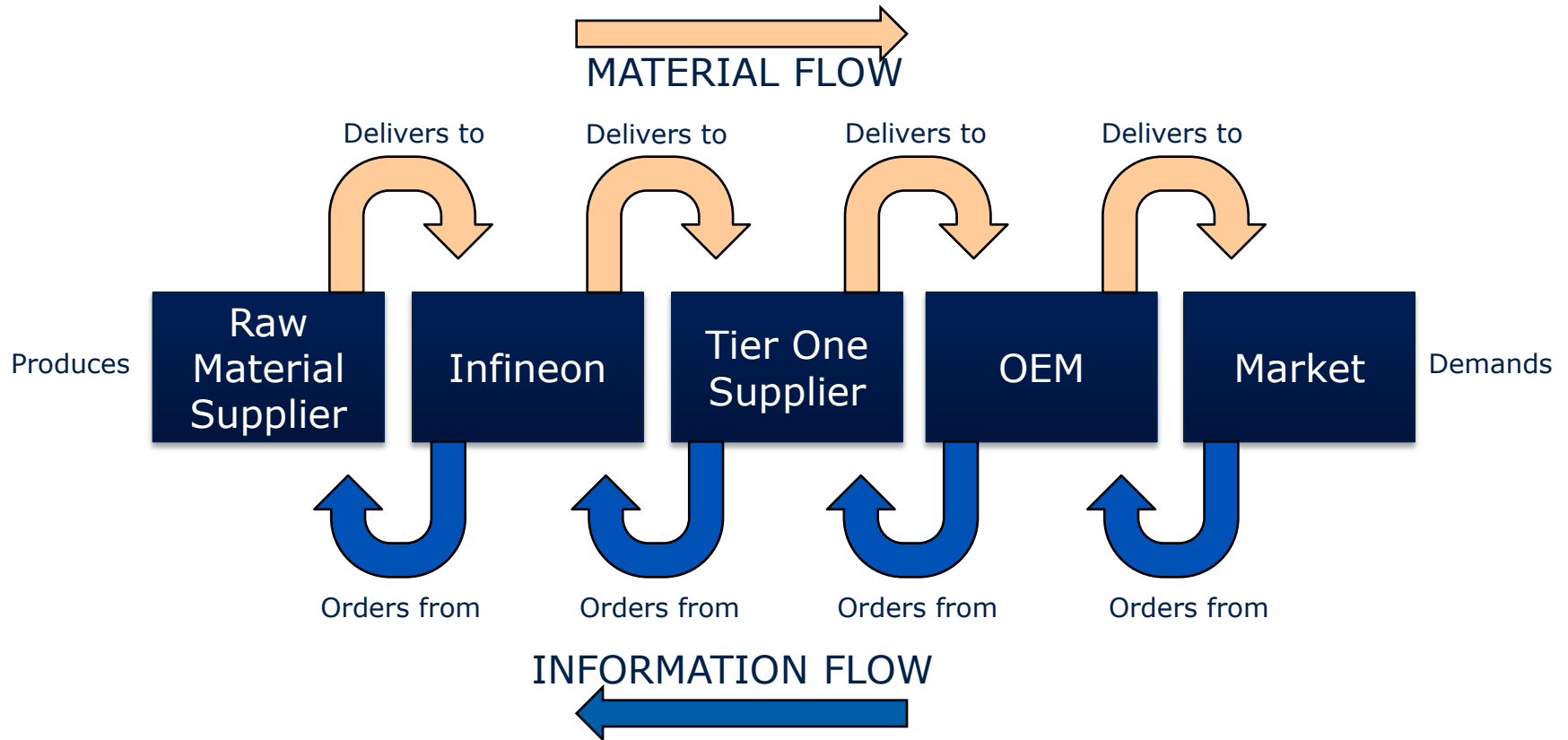
■ **Model Description**

■ Results

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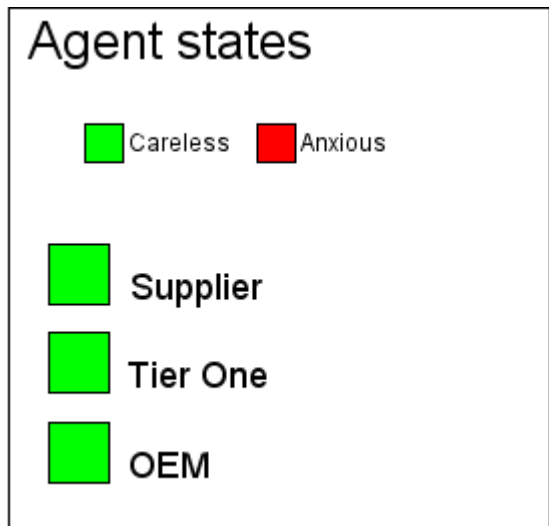
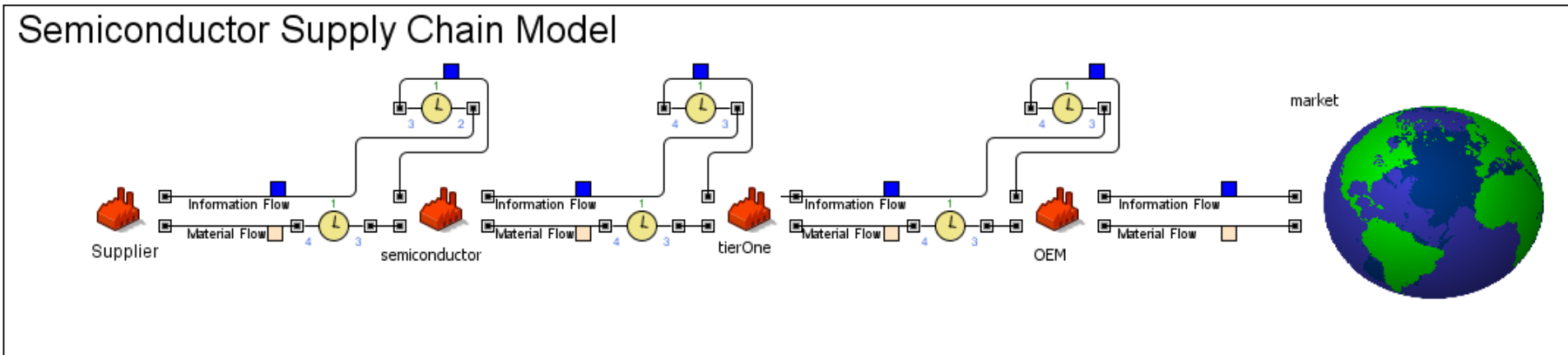
Model description (General)

- The supply chain model consists of 5 main agents:



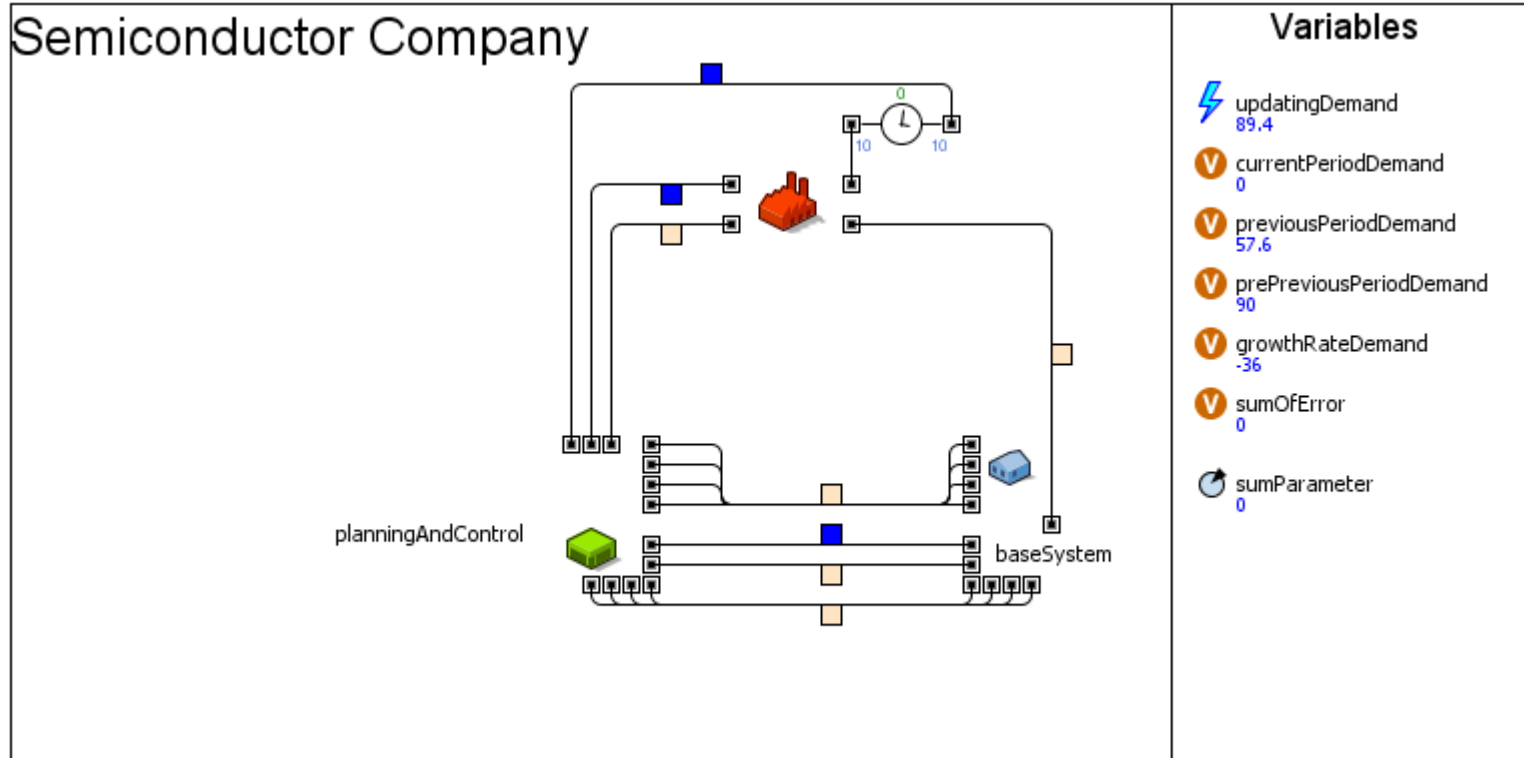
Model description (General)

■ Main view in Anylogic®:



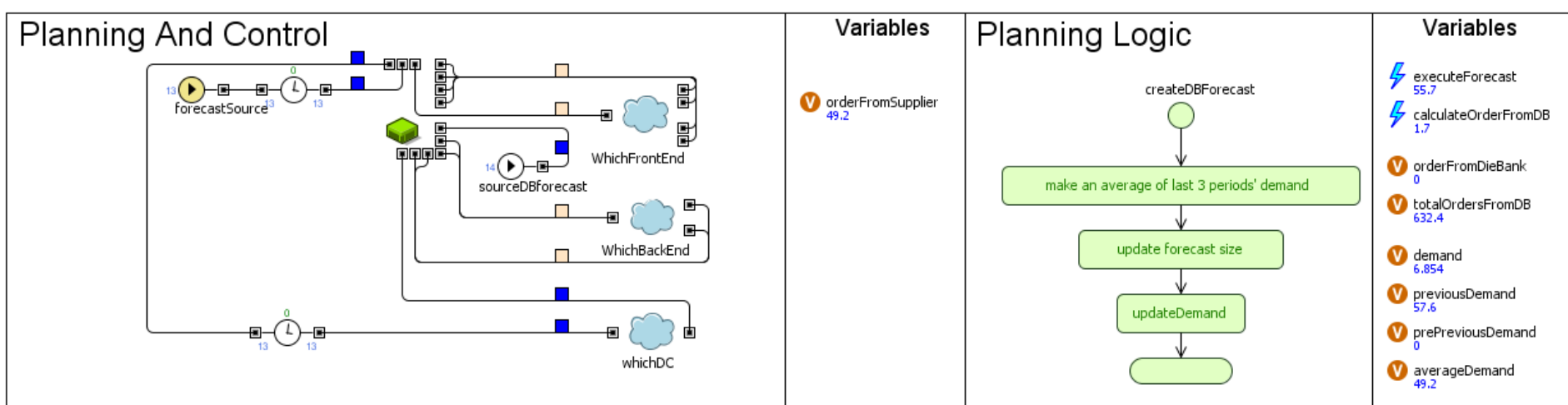
Model description

- The Semiconductor Agent consists of
 - **Planning & control** – where capacity decisions are taken and where forecasts & orders are made
 - **Base system** – where material is flowing and orders are executed



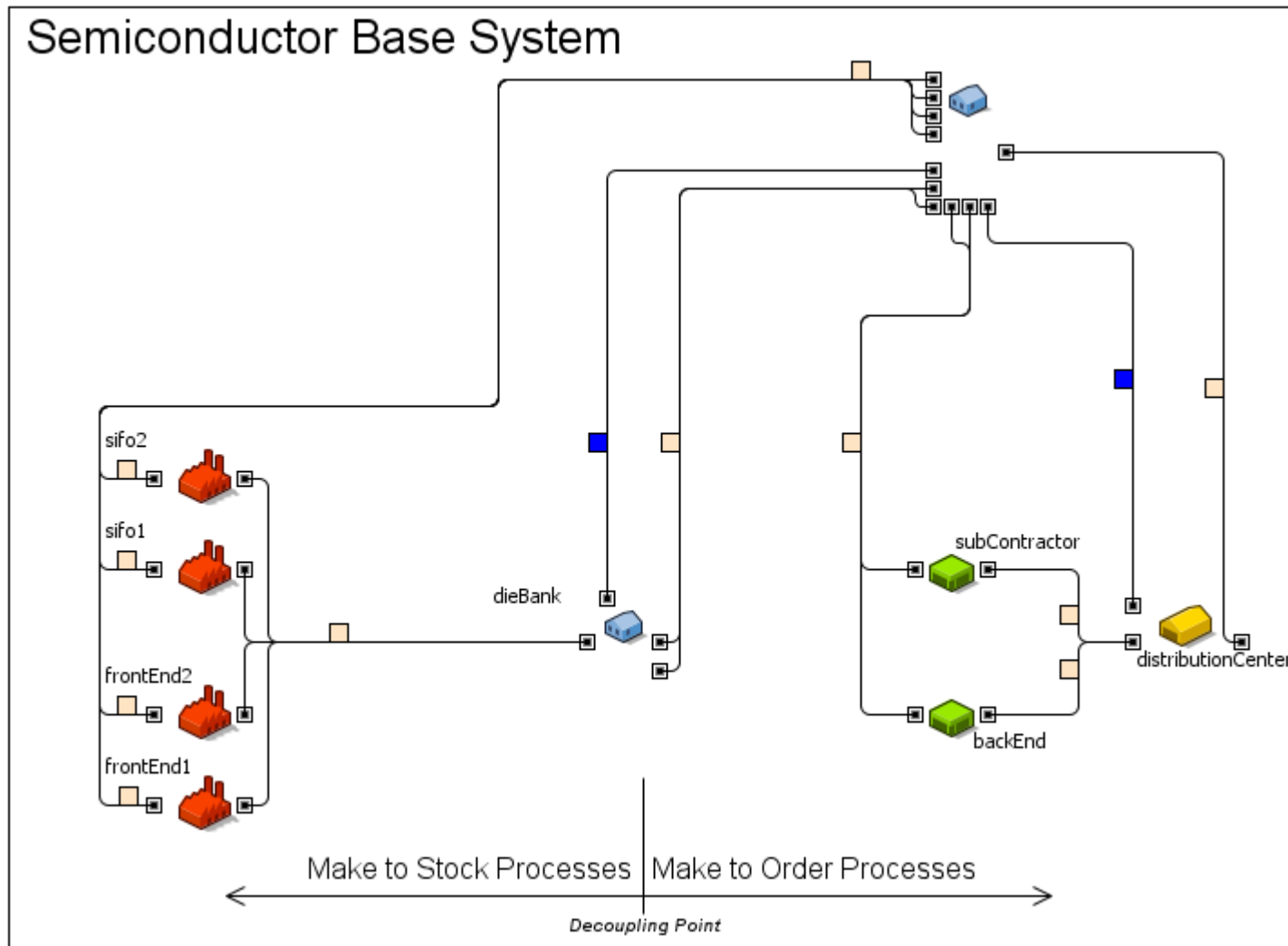
Model description (Planning & Control)

■ Screenshot from Planning and Control:



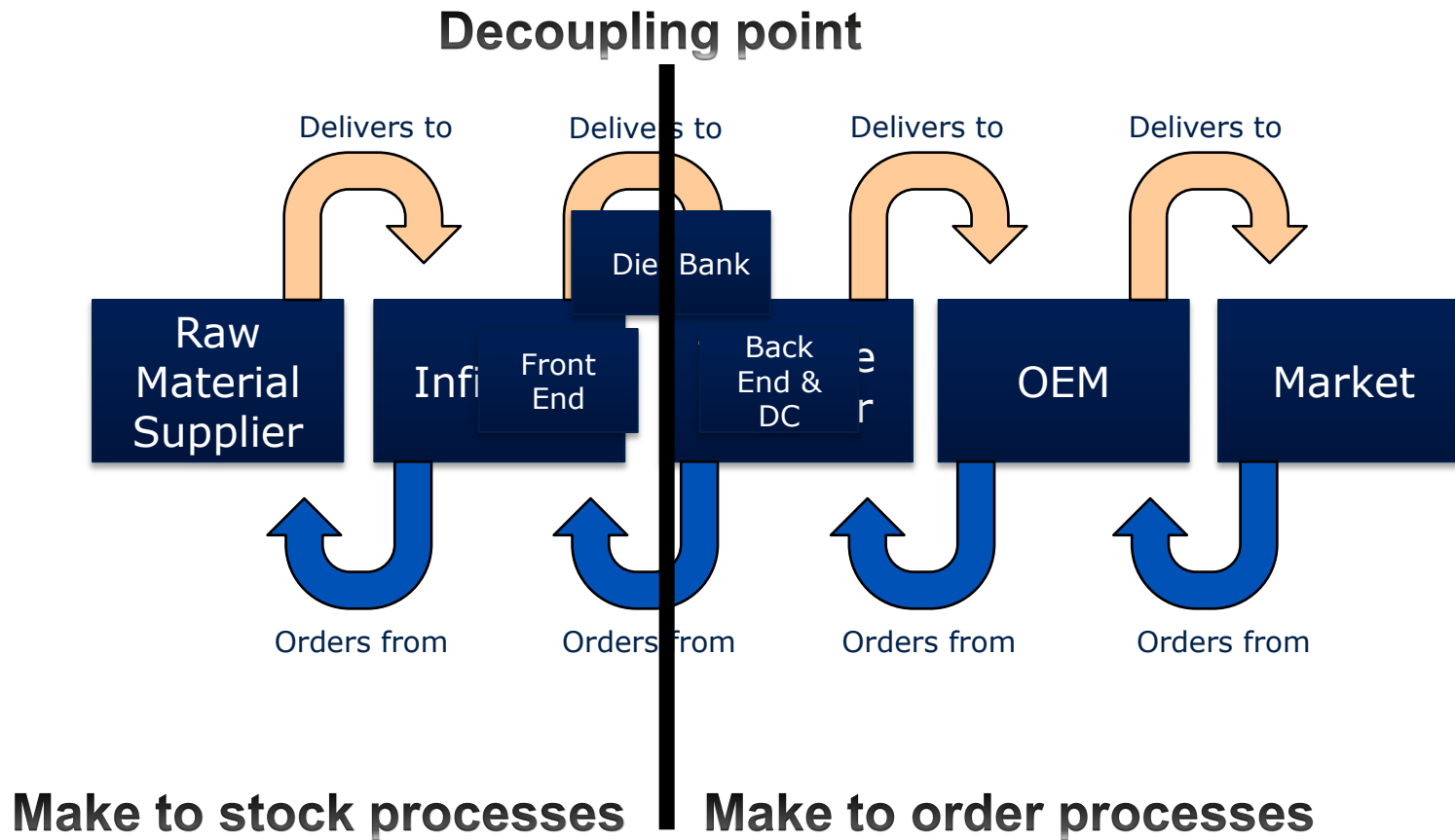
Model description (Base System)

- Screenshot from Base System:



Model description (General)

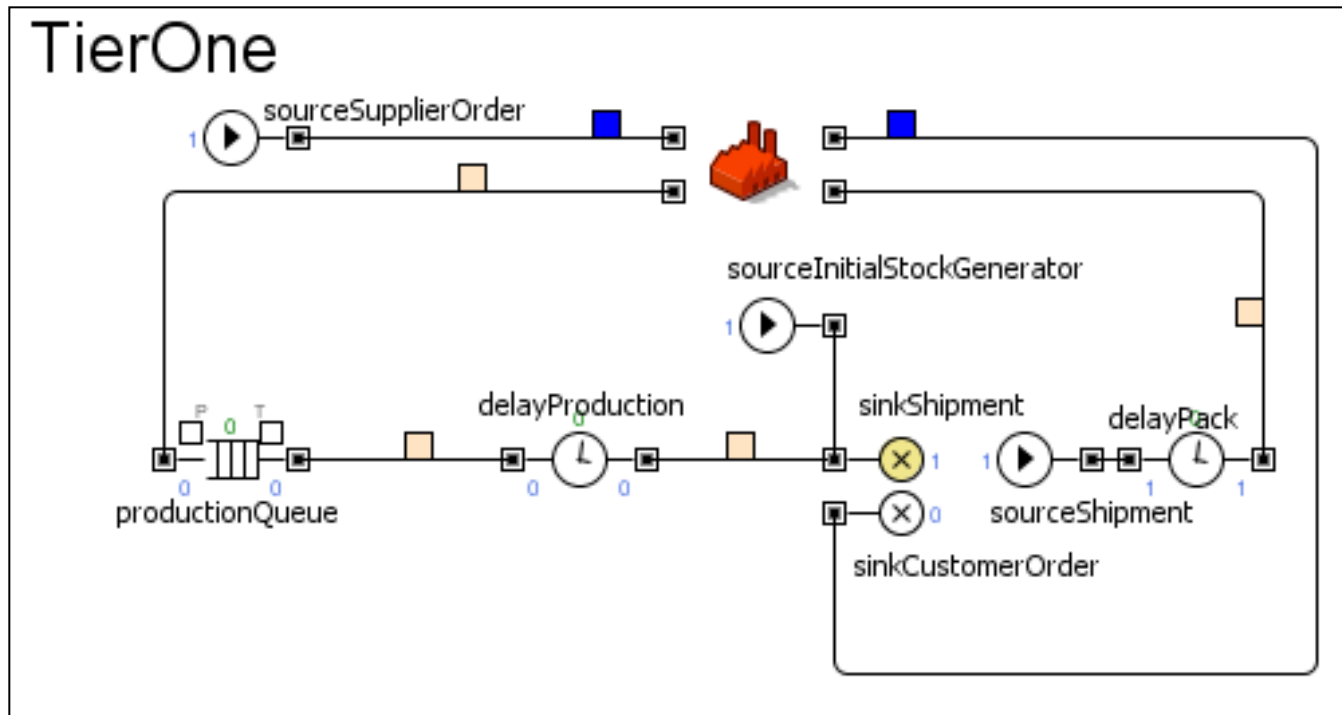
- The Decoupling point is at the Infineon Die Bank:



Note: Make to stock process based on an average demand forecast by Semiconductor Planning and control agent and a target stock at semiconductor DC agent.

Model description (Agents 1)

- Agents outside the Semiconductor manufacturer are modeled identically:
 - Agents produce generic output (information flow is delayed in the supply chain)
 - Agents have two states: "Careless" and "Anxious" determined by inventory reach
 - Agent over-orders when anxious (+ 20 % of demand)
 - Agent under-orders when Careless (- 50 % of demand)



Model description (Agents 2)

- Screenshot from Agent outside Infineon:

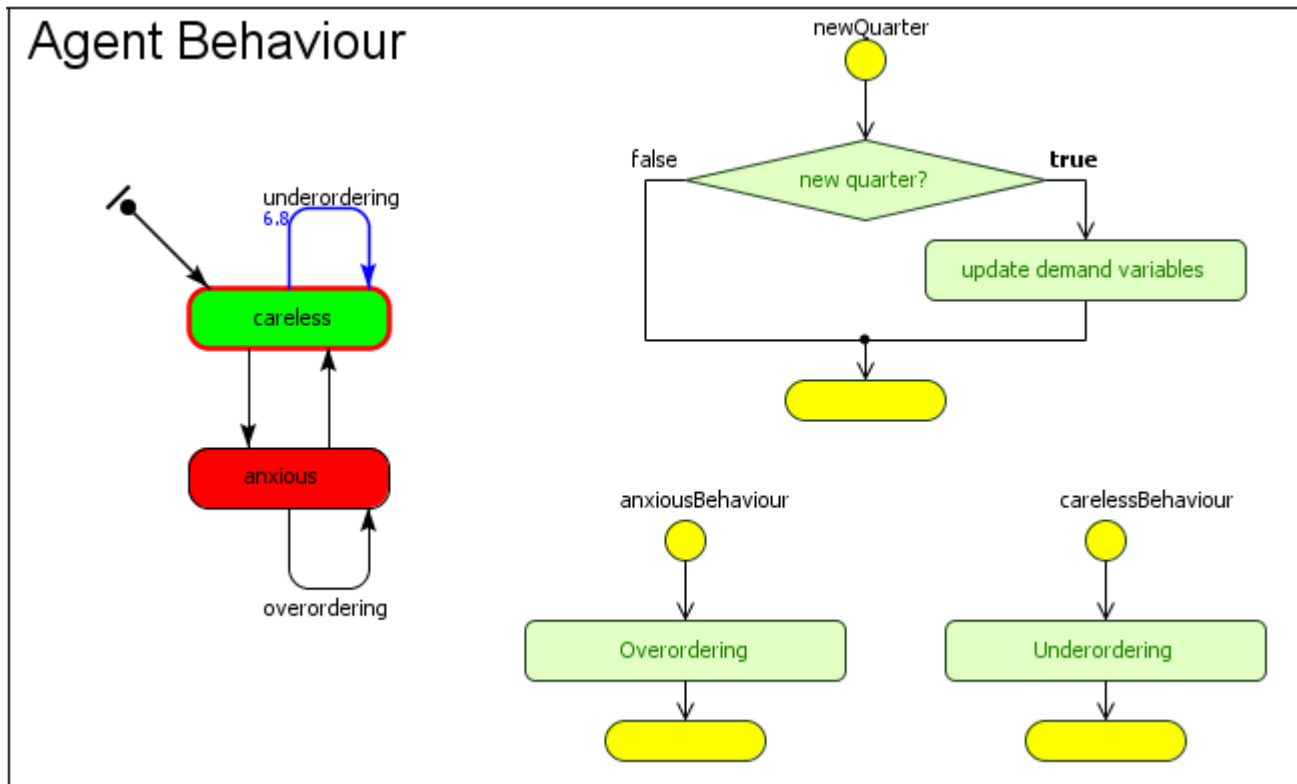


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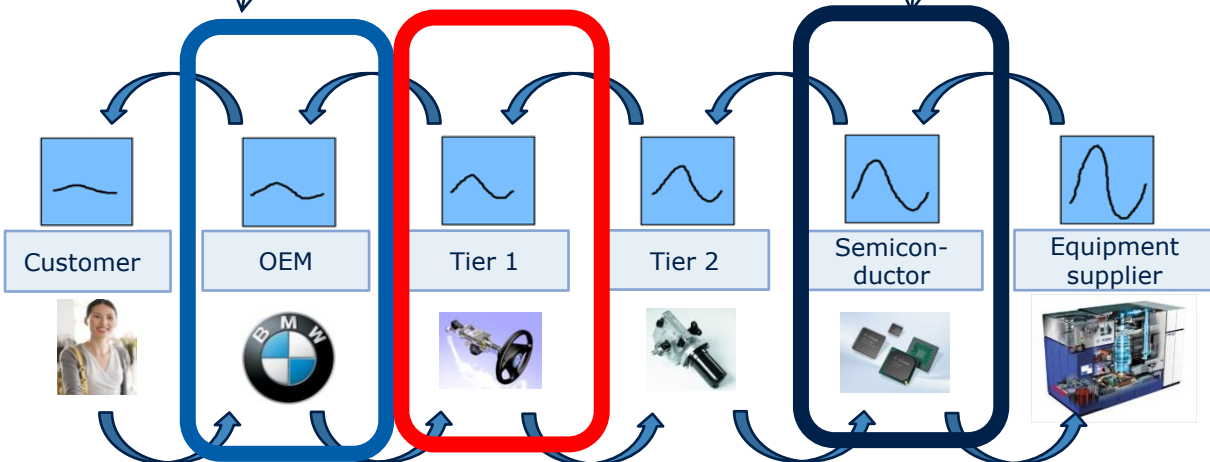
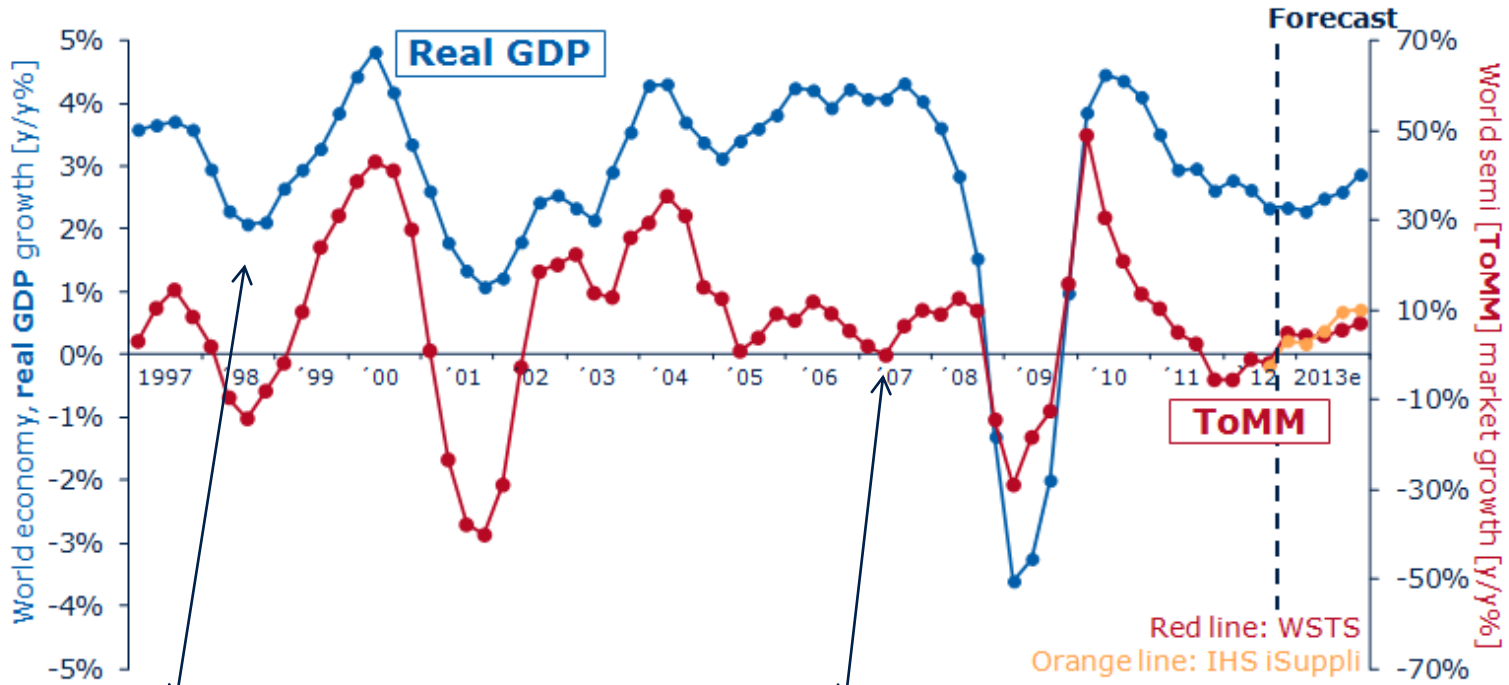
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■ **Results**

■ Impressions & Lessons Learned

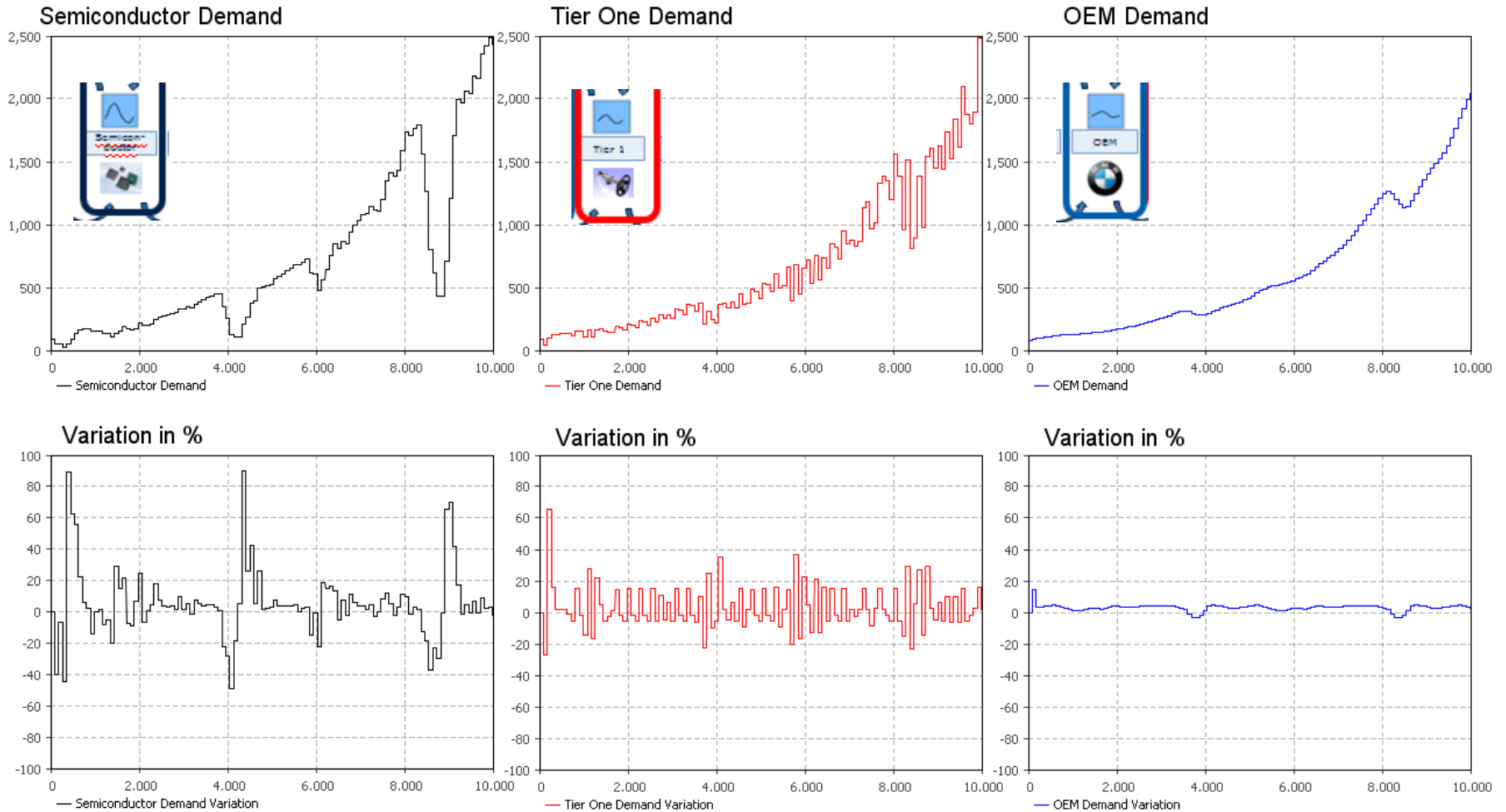
We wanted to show the Bullwhip = Amplification of demand along the supply chain



Bullwhip Effect
Overshooting in the value chain

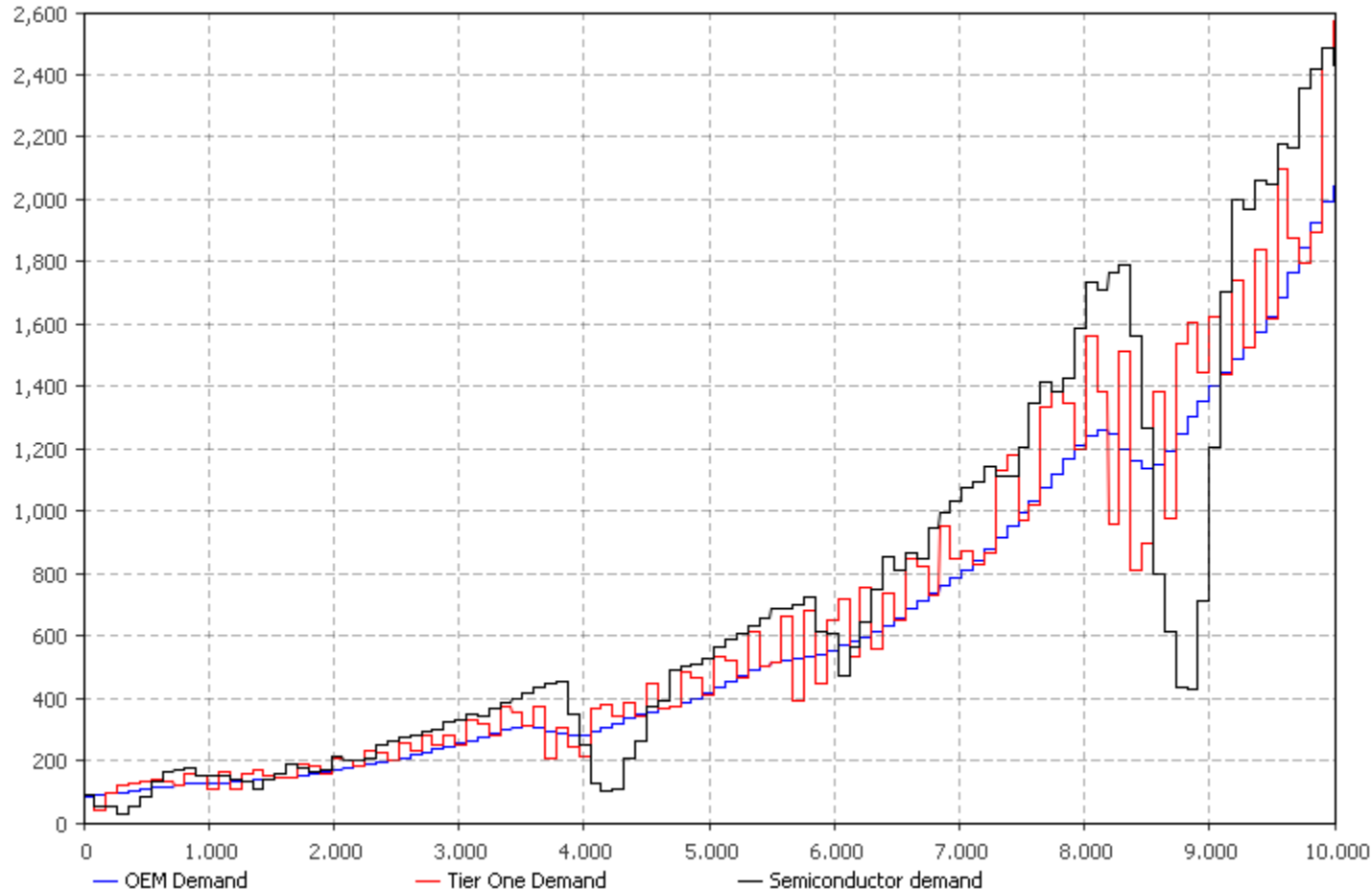
Results show that the bullwhip effect can be seen (1)

Resulting demand fluctuations by SC level:



Results show that the bullwhip effect can be seen (2)

■ Resulting demand fluctuations:



Global Demand



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Impressions & lessons learned

■ Easy to use functionality

- UI very user-friendly
- This applied also without extensive previous knowledge of programming or simulation

■ Satisfying set of functionalities

- Particularly the option to combine discrete & agent-based modeling techniques (as in this model)
- Systems dynamics functionality not used although it exists in AnyLogic

■ Provides visually attractive results

- 2D and 3D representation options



Summary

- This model combines **discrete event-based simulation** with **agent-based simulation** to represent the bullwhip effect in the supply chain.

- Main conclusion is that AnyLogic is **easy to use** and has **good functionality** for SC discrete and behavioral simulation.

- Especially unique attribute of AnyLogic:
 - **Ability to combine** agent-based and discrete modeling techniques (and system dynamics techniques) in one model.





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