To Main Proceedings Document

Supply Chain Management

Software Solutions versus Policy Design

Jürgen Strohhecker

SIMCON GmbH
Friedrich-Ebert-Str. 70
D–68723 Schwetzingen
GERMANY
E-Mail: jstr@gmx.de

Business School of Banking and Finance (HfB)
Sternstraße 8
D–60318 Frankfurt am Main
GERMANY

1 Why Supply Chain Management?

Since the mid-90s Supply Chain Management (SCM) is becoming more and more popular. The companies rediscover the optimization of planning and controlling the production and logistics networks as a key factor of success. In the context of a European Research Project (DELPHI Project No. 26965) a field survey of 644 companies in Europe shows that only 14 % of these companies haven’t heard anything about SCM and more than ¾ intend to engage in SCM improvements within the next three years.

As interviews carried out all of the interviewed companies use a software system supporting production planning and control. However, more than 90 % are not satisfied with it and mention significant weak points. Hence, most of the companies seem to intensify their SCM activities because of their disappointment with the results provided by their MRP or ERP software system. They assume that they will solve all or most of their problems by expanding the existing software solutions with components of SCM software. Software manufacturer see increasing possibilities of making money and therefore do everything to encourage their clients in this belief. As studies of the American Manufacturing Research Institute show the strategy of the software manufacturer is obviously very successful. A market volume of 19.3 Billions of Euro is expected in 2003 for SCM software – an increase of more than 700 % compared to 1998.

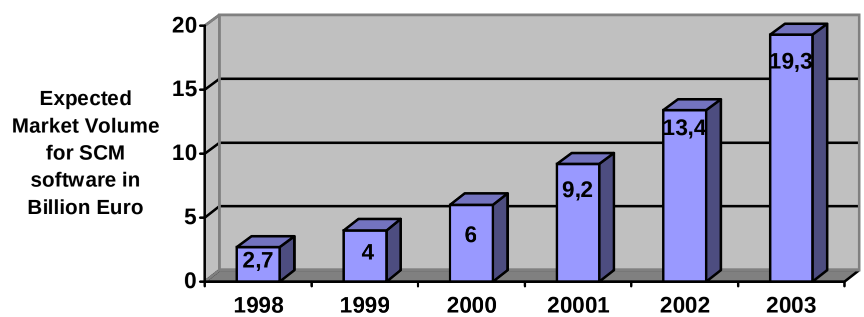

Figure 1: Expected Market Volume for SCM Software[1]

However, it seems to be doubtful whether the solely software solution brings the success the companies hope for. Assuming that the integration of software systems along all elements of the supply chain will improve the quality and speed of information

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1 AMR Research, Inc, 1999

flows, the result should be lower cycle time and cost. SCM, however, has a much bigger success potential. If the elements along the supply chain coordinate their order und delivery policies and stay with these policies, they should outperform pure software solutions easily.

To confirm or reject this conjecture a model based system dynamics study is performed. Simulation experiments are conducted to show the effect of different interventions.

2 Supply Chain Reference Modes and Model Structure

Regardless whether industry is under investigation most supply chains show a similar dynamic behavior. Typical for supply chains are[2]

- oscillations in orders and stocks even if the market demand is almost constant except small random variations.
- increasing amplitudes of oscillations along the supply chain.
- high levels of excess inventory at the end of product life cycles.
- increasing surplus inventory along the supply chain.

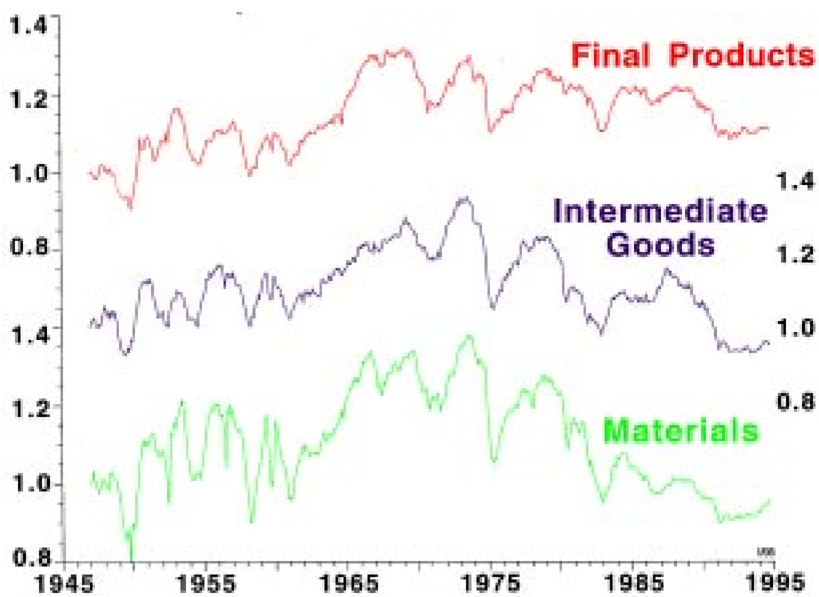

Figure 2: Oscillation and Amplification in the US Economy

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2 See Jay W. Forrester: Industrial Dynamics, 1961, p. 28–29. Peter M. Senge: The Fifth Discipline, 1990, p. 27–39. John D. Sterman: Business Dynamics, 2000, p. 743–749.

Figure 2 illustrates oscillation and amplification using the example of the US economy.

The system dynamics supply chain model used in the following investigation is based on Forrester's work presented in his "Industrial Dynamics"[3]. Compared to the original Forrester model the following major extensions are made:

- A contractor is added to the supply chain. Therefore the supply chain comprises four stages: retailer, distributor, factory and contractor. The contractor supplies the factory with parts for the product. The structure of the contractor module is very similar to that one of the factory.
- The production capacity of both factory and contractor are modeled as variable. That is why policies for increasing and decreasing production capacity when demand is changing are added.
- Quality management and quality control have become very important for companies. Therefore a quality control stage is modeled as extension to the manufacturing process.
- Supply Chain Management has a lot to do with cooperation and trust. For taking this into consideration some equations are added modeling the development of confidence in the other supply chain partners.

When the model is simulated with noisy customer orders as test input a typical supply chain dynamic behavior is the result. Figure 3 shows oscillating incoming orders with increasing amplitude along the supply chain.

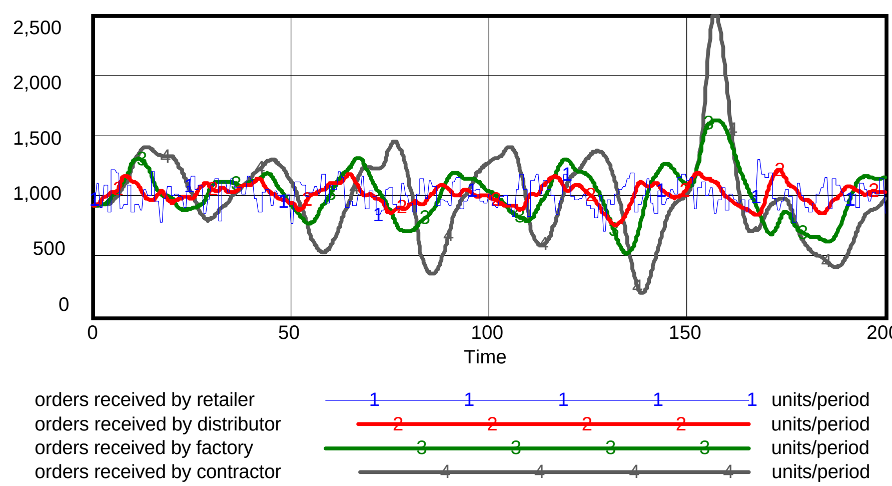

Figure 3: Supply Chain Reference Dynamics – Incoming Orders in the Base Case of Noisy Demand

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[3] See Jay W. Forrester: Industrial Dynamics, 1961, p. 21–35 and p. 135–186.

Figure 4 shows the dynamics of inventories in the base case of noisy customer demand. As in Figure 3 there are oscillations with amplification along the supply chain.

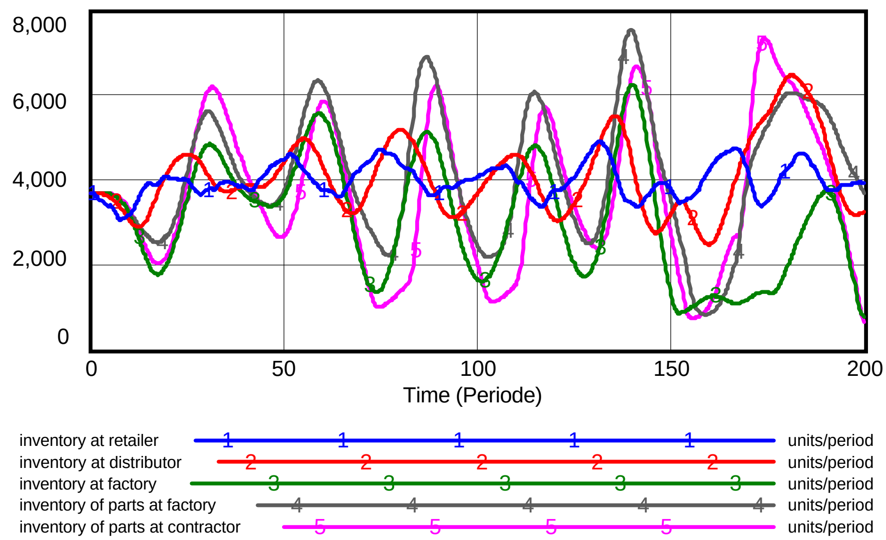

Figure 4: Supply Chain Reference Dynamics – Levels of inventory in the Base Case of Noisy Demand

The life cycle demand test input is generated by a Bass diffusion structure.[4] The orders received by the retailer show the smooth course similar to a normal distribution. The average of orders over the whole life cycle is as in the case of noisy demand 1,000 units per period.

The supply chain reference modes in the case of life cycle demand are shown by Figure 5 and Figure 6. Again oscillations occur, and the amplitude is increasing along the supply chain. The levels of inventory in the supply chain are high at the end of the product's life. Especially the inventory of goods in the factory is in period 200 almost as high as at the peak around period 100.

The base case simulations show that the system dynamics supply chain model is able to produce the characteristic dynamic behavior that one can find in real supply chains. Therefore it seems to be a useful tool for experiments with different Supply Chain Management strategies.

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4 See Frank M. Bass: A New Product Growth Model for Consumer Durables, in: Management Science, Vol. 15, Nr. 5, January, 1969, p. 215–227. See also Peter Milling: Diffusionstheorie und Innovationsmanagement, in: Erich Zahn (Hrsg.): Technologie- und Innovationsmanagement, Berlin, 1986, S. 49–70.

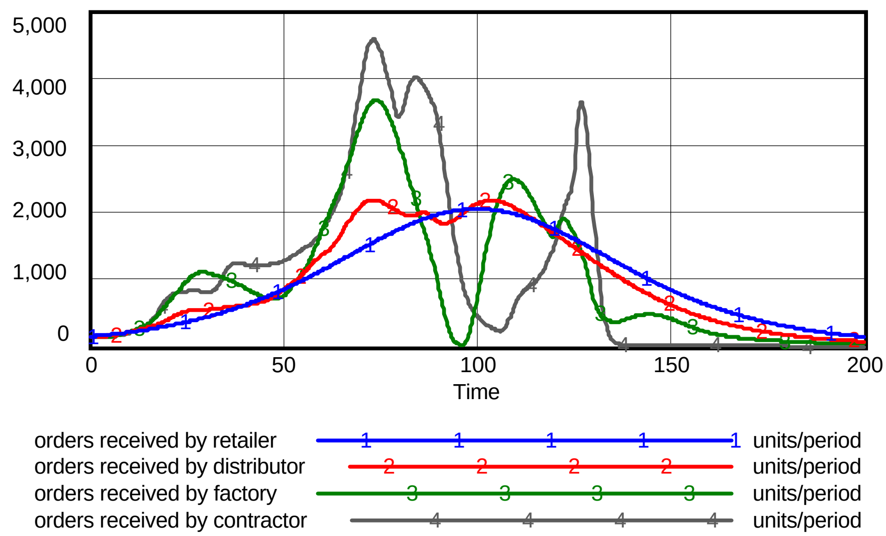

Figure 5: Supply Chain Reference Dynamics – Incoming Orders in the Base Case of Life Cycle Demand

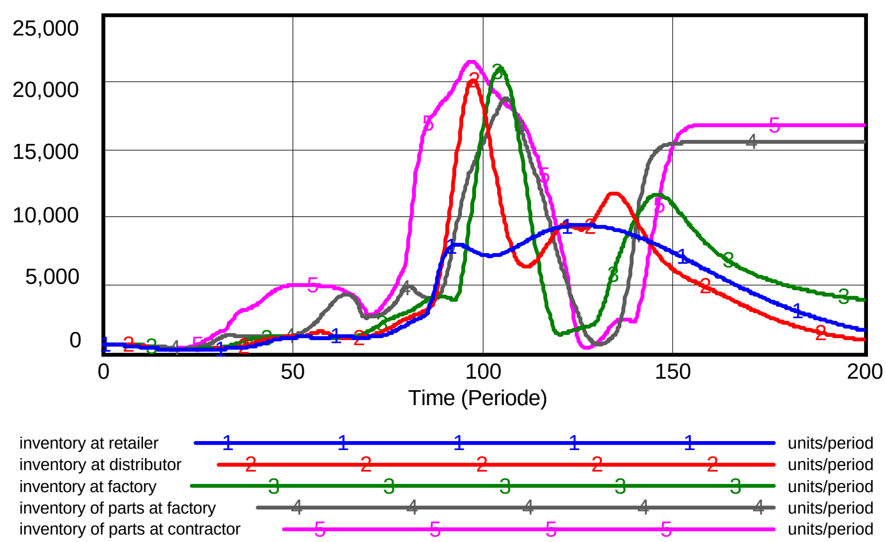

Figure 6: Supply Chain Reference Dynamics – Levels of inventory in the Base Case of Life Cycle Demand

3 Simulation Results of Supply Chain Management Practices

Most of the companies offering SCM software and consulting use catchwords in their marketing like quick response systems, vendor management inventory systems, efficient consumer response systems or continuous replenishment systems.[5] There are however some core concepts behind all these slogans. First of all a very common SCM practice is to speed up information flows and order processing activities. Electronic data exchange is introduced and reduces the transportation delay for orders dramatically. Secondly most SCM systems try to improve the forecasts of incoming orders. Therefore several trend extrapolation techniques are usually made available in the software systems. The goal is to substitute the wide spread estimates of future orders based on individual experience. In a third step mechanisms are provided for exchanging and synchronizing the individual forecasts along the supply chain.

Having the system dynamics supply chain model described above it is possible to simulate these common SCM practices. Speeding up information flows and order processing results in shorter delay times. It is assumed that the order processing delay

- between retailer and wholesaler is reduced to almost one quarter,
- between wholesaler and factory is reduced to 40 % and
- between factory and contractor is reduced to 2/3.

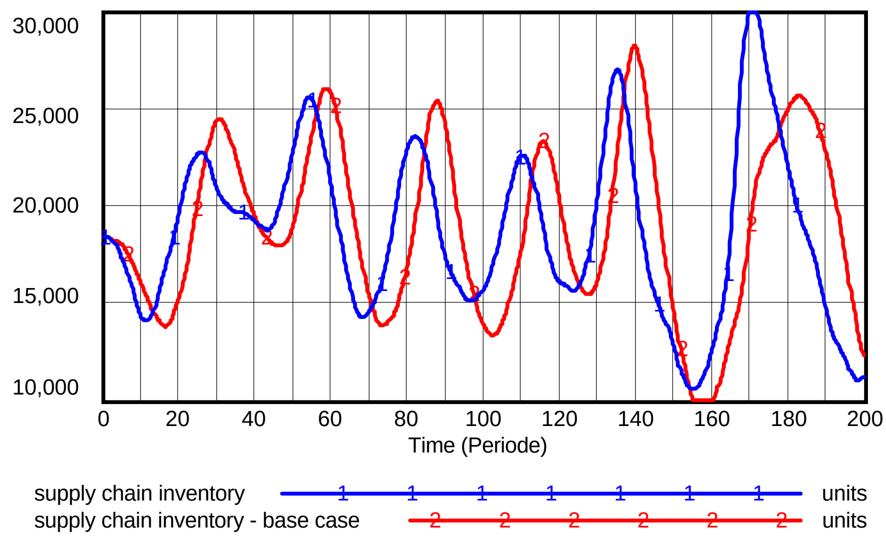

Figure 7: The Effect of Speeding Up Information Flows on Supply Chain Inventory in the Case of Noisy Demand

The effect of this simulation experiment on the inventory of the whole supply chain shows Figure 7. It is obvious that the typical

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[5] Have for example a look at:
http://www.sap.com/solutions/scm/index.htm
http://www.baan.com
http://www.i2.com

oscillations in inventory are not restrained. There is however a postponement of the curve. This means that faster order processing and transportation results in a quicker response to steps in customer demand. As Figure 8 illustrates new levels of customer demand are communicated faster through the supply chain. This reduces the oscillation intensity of inventories and therefore the level of costs.

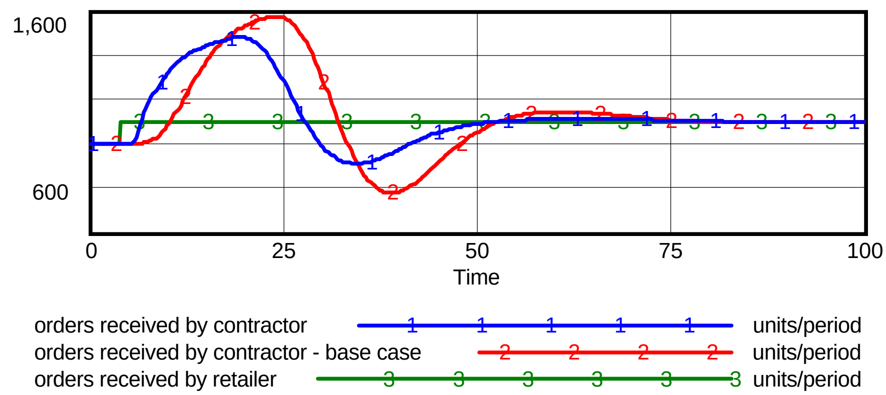


Figure 8: Effect of Faster Order Processing on the Orders Received by the Contractor in the Case of a Step in Customer Demand

That speeding up information flows and order processing is positive shows another simulation experiment with life cycle demand as test input. As Figure 9 indicates the peak in supply chain inventory is reduced by 25 % through shorter delay times in the information flows. To a significant less degree the high surplus levels of inventory are decreased at the end of the product life cycle.

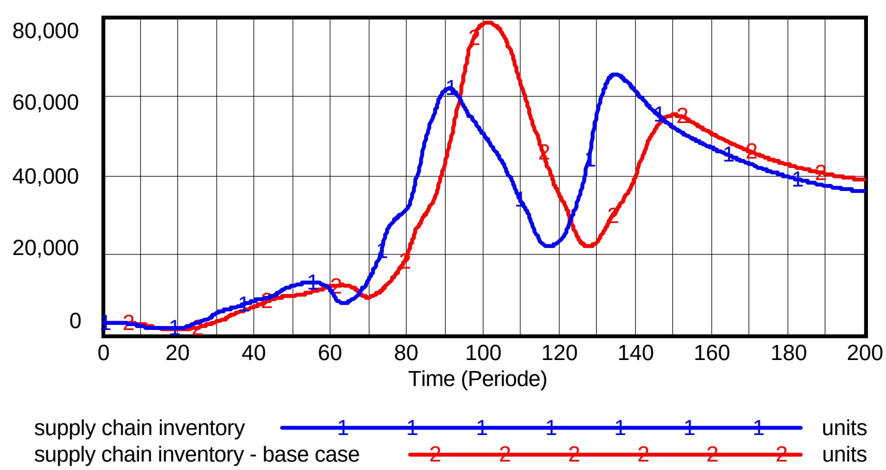


Figure 9: The Effect of Speeding Up Information Flows on Supply Chain Inventory in the Case of Life Cycle Demand

More effect on inventories has the optimization of forecasts. In the base run each member of the supply chain uses a simple trend extrapolation forecast of the future value of incoming orders based on its past behavior. The trend extrapolation forecast is modeled using Vensim's forecast function with an average time of 24 periods and a horizon of 6 periods.[6] The optimization of these two forecast parameters – separately for each supply chain stage – leads to a much better performance of inventories compared to the reference scenario with life cycle demand. Figure 10 confronts these two scenarios.

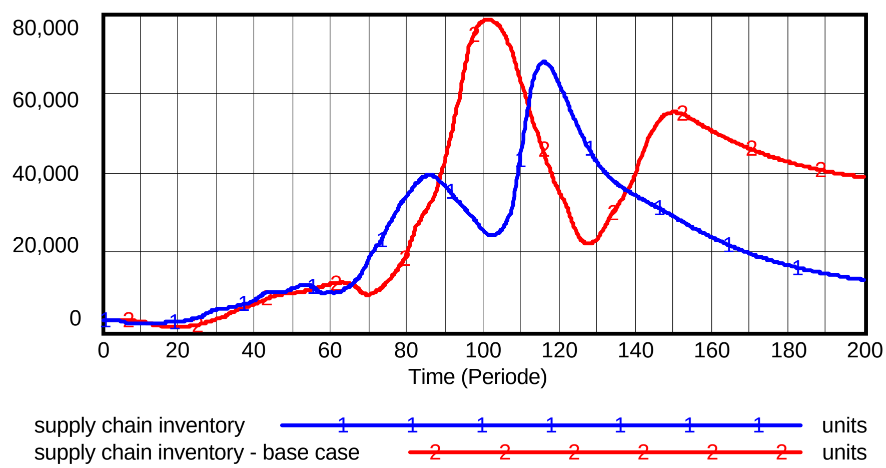


Figure 10: The Effect of Optimized Demand Forecast on Supply Chain Inventory in the Case of Life Cycle Demand

If all the supply chain members cooperate in the field of forecasting the demand and exchange data the effect of surplus inventory at the end of the product life cycle can be extremely reduced as Figure 11 indicates. It is true that the level of inventory is higher in the early stages of the product life cycle, but no expensive sales activities are necessary to sell the surplus inventory at the end of the life cycle. Therefore the total supply chain costs will be less compared to the base case in spite of higher inventory costs.

6 See Ventana Systems, Inc.: Vensim® 4 Reference Manual, 1999, p. 73.

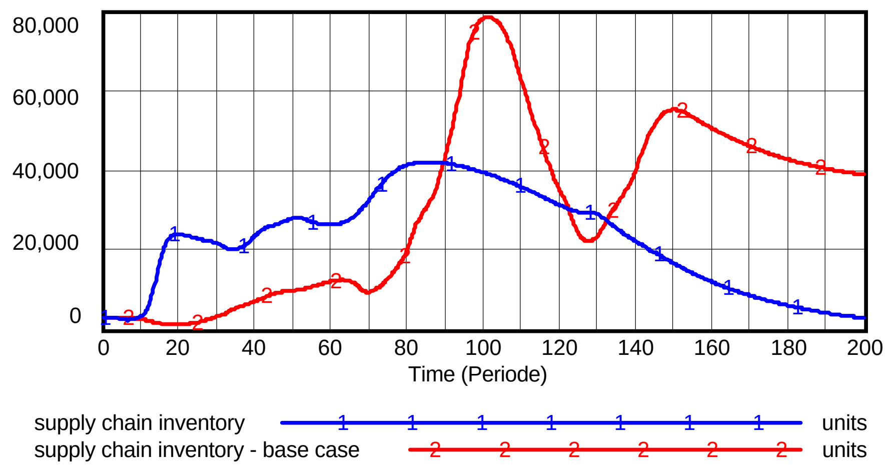


Figure 11: The Effect of Optimized and Synchronized Demand Forecast on Supply Chain Inventory in the Case of Life Cycle Demand

As Figure 12 shows, synchronizing and optimizing the demand forecast in the supply chain has a positive effect on inventory oscillations in the case of noisy demand too. Therefore it is really worth wile to intensify cooperation and data exchange along the supply chain even if the demand takes an almost constant course.

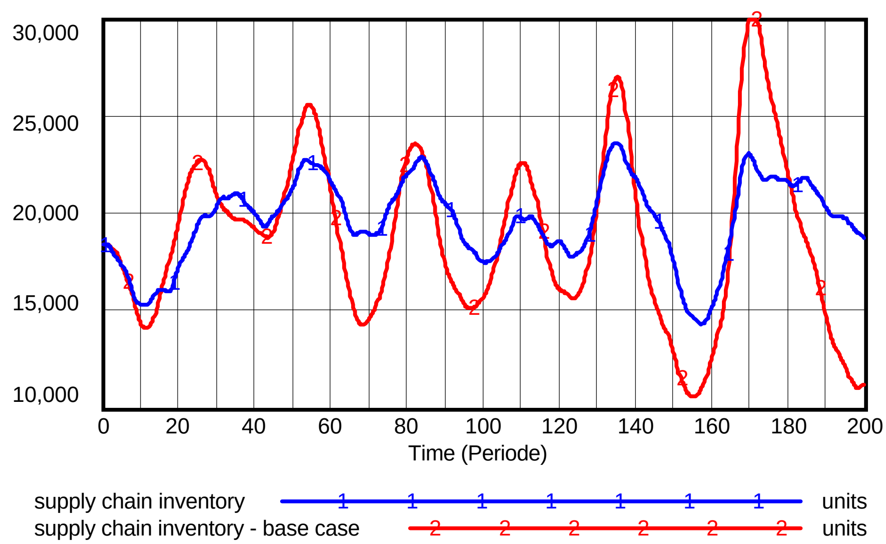


Figure 12: The Effect of Optimized and Synchronized Demand Forecast on Supply Chain Inventory in the Case of Noisy Demand

All the optimization strategies discussed up to now are however not able to change the general level of inventories in the supply chain and to speed up the cycle time (see Figure 13 and Figure 14).

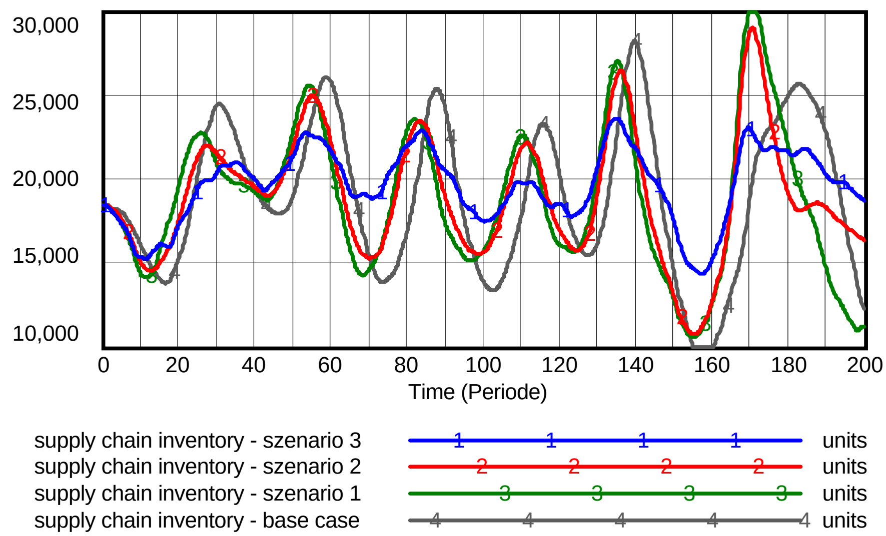


Figure 13: The Level of Supply Chain Inventory in the Different Scenarios Discussed (Noisy Customer Demand)

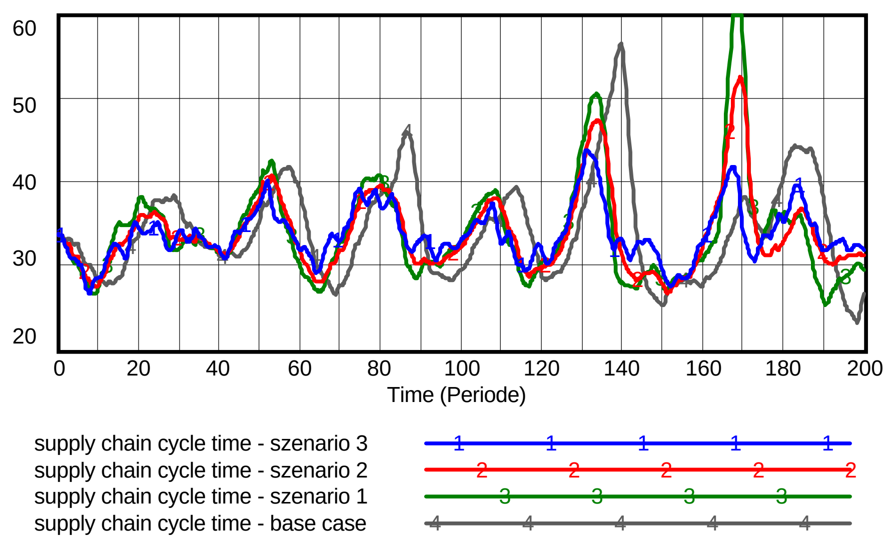
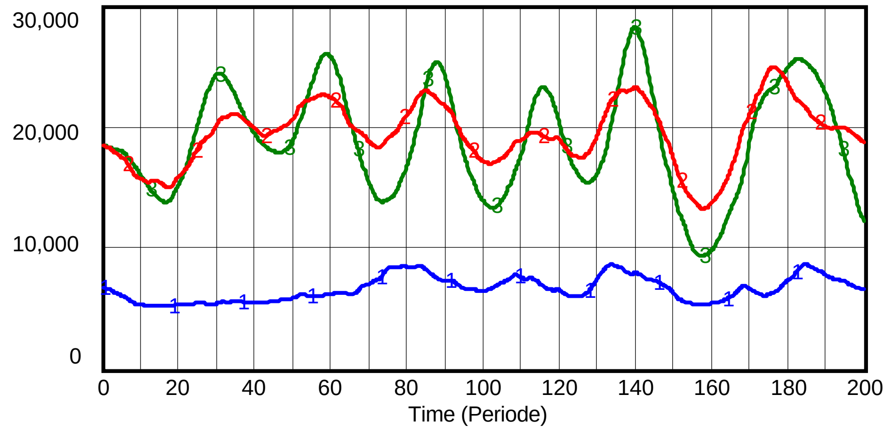


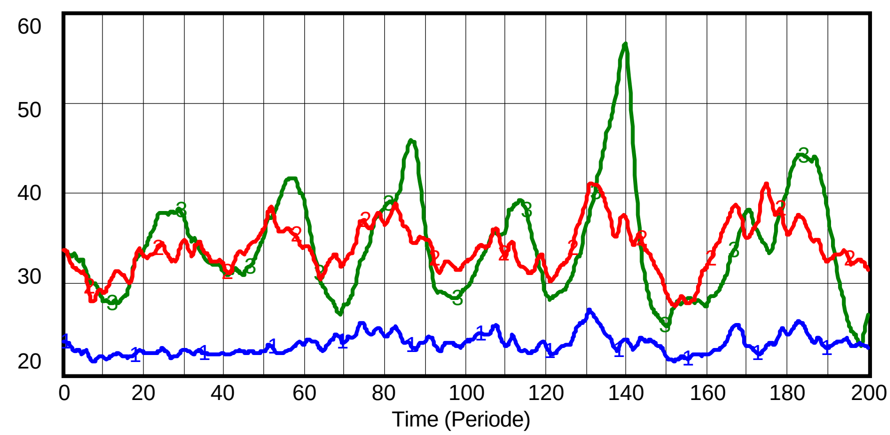
Figure 14: The Supply Chain Cycle Time in the Different Scenarios Discussed (Noisy Customer Demand)

For a better overall performance of the supply chain, especially for lower levels of inventories and reduced cycle time, changes in the policies of all supply chain members are necessary. Optimizing the decision rule determining the level of desired inventory results in dramatically lower supply chain inventories and reduces the supply chain cycle time by one third (see Figure 15 and Figure 16).



supply chain inventory - optimized policy — 1 — units
supply chain inventory - optimized software — 2 — units
supply chain inventory - base case — 3 — units

Figure 15: The Supply Chain Cycle Time in the Different Scenarios Discussed (Noisy Customer Demand)



supply chain cycle time - optimized policy — 1
supply chain cycle time - optimized software — 2
supply chain cycle time - base case — 3

Figure 16: The Supply Chain Cycle Time in the Different Scenarios Discussed (Noisy Customer Demand)

4 Conclusions

Using a system dynamics supply chain model based on Forrester's work presented in his "Industrial Dynamics", different strategies to improve performance of the supply chain are implemented in the model and simulated. Assuming that the integration of software systems along all elements of the supply chain will improve the quality and speed of information flows, the simulation shows lower oscillations of inventories and lower surplus inventories at the end of a product life cycle. SCM, however, has a much bigger success potential as further simulations show. If the elements along the supply chain coordinate their order und delivery policies and stay with these policies, they will outperform pure software solutions easily.

5 References

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