Analysing the Impact of Forecasting and Demand Patterns in Supply Chains

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Extended Abstract

Introduction: System Dynamics has been recognized as an invaluable tool for analysing and designing supply chains (Klug, 2013) since Forrester's phenomenal study of Industrial Dynamics (Forester, 1958). Many researchers have proposed numerous studies about different replenishment structures and inventory management policies using system dynamics methodology (Torres and Moran, 2006). Although simulation tools are not designed for precise forecasting and modellers use limited number of functionalities, calibrated system dynamics models are likely to be more informative than those from other approaches (Lyneis, 2000). Forecasting is the trigger of material flows in demand-driven supply chains and has always been a popular area for supply chain management researchers and practitioners. However, quantifying the impact of forecast accuracy on system performance is a challenging task. It takes time for the numbers to emerge and managerial decisions to invest in this area in terms of technology, process and organisation may be overruled by delays. In this study, we propose a methodology where we take forecast as a probability distribution of demand and assess the performance over time with various accuracy levels for both unseasonable and seasonal demand patterns. In addition, we enrich the model with strategic growth targets and temporary demand jumps such as promotional occasions and demand decreases and conclude with other possible additions.

Methodology: We propose a methodology where we start by conducting a statistical analysis of historic sales and identifying seasonality patterns of demand. The outcome of this analysis enables us to determine the probability distribution of historic sales. In case there is an observed seasonality of the demand, we deseasonalize the historic data and generate the probability distribution afterwards. In System Dynamics model, forecast is generated based on the obtained probability distribution and seasonal adjustments are conducted to generate the supply plan by using calculated seasonality indexes. In order to model the supply plan, we use supply chain infrastructure as a dynamic system (Sterman, 2000) and for multi-echelon structure we use Advance Forecast-sharing Coordination (AFC) model (Moran and Barrar, 2006).

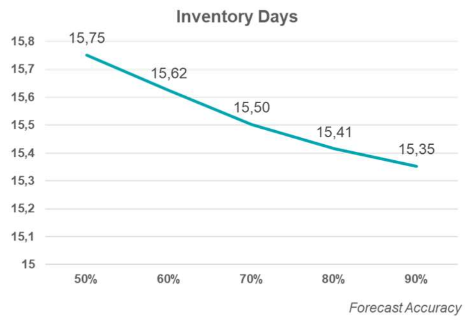
Having the forecast and supply plan, our first objective is to analyse the supply chain performance under various forecast accuracy levels. Hence, we generate the market demand as a combination of forecast and uniform distribution of forecast accuracy to ensure market demand is distributed around forecasted demand within forecast error boundaries.

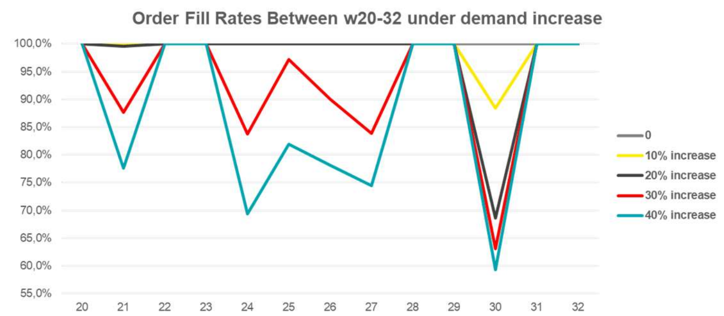
$$D = F[x(b - a) + a]$$

where; D: market demand, F: forecasted demand, x: generated random number and a and b: lower and upper parameters of obtained uniform distribution respectively.

Our second objective is enriching the model with strategic growth targets such as pre-set annual budgets. To do so, we determine the target and strategy horizon and assign the trend with RAMP function. Finally, we simulate the demand increase or decrease which occurs for a specific period within simulation horizon. This scenario is generated via combining demand increase or decrease rates, number of periods for demand change with PULSE function. Keeping the forecasted demand arising from the probability distribution unchanged, the system will only try to adjust the inventory and we observe the changes in performance overtime in terms of inventory and service levels, precisely order fill rates. This would enable us to address the importance of advance demand information.

Results: We have conducted the proposed methodology in two supply chain structures using Vensim® simulation tool by Ventana Systems. The first application is carried out in a consumer electronics distributor with a single-echelon supply chain while the second application is carried out in a major domestic appliance manufacturer having a two-echelon supply chain. Assigning various numeric values to forecast accuracy and running continuous-time based simulations, we have observed how inventory levels and inventory turns as well as order fill rates differ under the given accuracy figures. We have also conducted research for demand increase and decrease scenarios at various levels for 8 weeks period in the simulation horizon of 52 weeks.





Conclusion: In this study we have analysed three areas of change in demand; forecast accuracy, strategic targets alignment and demand increase or decrease for a specific period. For the latter two, we have defined the horizon and change ratios and combining them with RAMP and PULSE functions respectively. For forecast accuracy analysis, we have used a uniform distribution in the SD model where market demand can vary between accuracy levels. The simulation results indicate;

- Accuracy of forecasts have a direct impact on supply chain performance in terms of inventory and service levels
- Inventory policies try to stabilize the supply chain system even in low forecast accuracy
- Stock adjustment takes more time in demand decrease scenarios

Although we have used a probability distribution for forecasting, same methodology can be applied to various and more advanced forecasting methods. We have involved forecast accuracy in the simulation model with a uniform distribution, but real data can indicate other distribution types for accuracy levels, and therefore is an open area for further studies.

References:

Aburto, L. and Weber, R. (2007) 'Improved supply chain management based on hybrid demand forecasts', *Applied Soft Computing*, 7(1), pp. 136–144. doi:10.1016/j.asoc.2005.06.001.

Disney, S.M. and Lambrecht, M.R. (2010) *On replenishment rules, forecasting, and the bullwhip effect in supply chains*. 2008th, Kolophon: LaVergne, Tenn., USA, 2010th edn. Hanover, Mass.: Now Publ (Foundations and trends in technology, information and operations management, Vol. 2.2007/08,1).

Forrester, J.W. (1958) 'Industrial dynamics: A major breakthrough for decision makers', *Harvard Business Review*, 36, pp. 37–66.

Hu, Y., Zhang, J. and Xu, Z. (2007) 'Asymmetric demand information's impact on supply chain performance and relationship under price-only contract', in *2007 IEEE International Conference on Automation and Logistics*. *2007 IEEE International Conference on Automation and Logistics*, Jinan, China: IEEE, pp. 2891–2896. doi:10.1109/ICAL.2007.4339075.

Klug, F. (2013) 'The internal bullwhip effect in car manufacturing', *International Journal of Production Research*, 51(1), pp. 303–322. doi:10.1080/00207543.2012.677551.

Lummus, R.R., Duclos, L.K. and Vokurka, R.J. (2003) 'The impact of marketing initiatives on the supply chain', *Supply Chain Management: An International Journal*, 8(4), pp. 317–323. doi:10.1108/13598540310490071.

Lyneis, J.M. (2000) 'System dynamics for market forecasting and structural analysis', *System Dynamics Review*, 16(1), pp. 3–25.

McCullen, P. and Towill, D. (2002) 'Diagnosis and reduction of bullwhip in supply chains', *Supply Chain Management: An International Journal*, 7(3), pp. 164–179. doi:10.1108/13598540210436612.

Moran, F.V. and Barrar, P. (2006) 'Supply Chain Dynamics: Structural Causes of the Bullwhip Effect', in Torres, O. C. and Moran, F. V., *The Bullwhip Effect in Supply Chains*. Palgrave Macmillan, pp. 71–94.

Ouyang, Y., Lago, A. and Daganzo, C.F. (2006) 'Taming the Bullwhip Effect: From Traffic to Supply Chains', in Torres, O. C. and Moran, F. V., *The Bullwhip Effect in Supply Chains*. Palgrave Macmillan, pp. 71–94.

Sterman, J.D. (1989) 'Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment', *Management Science*, 35(3), pp. 321–339. doi:10.1287/mnsc.35.3.321.

Sterman, J.D. (2000) *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hill Higher Education.

Terwiesch, C. *et al.* (2005) 'An Empirical Analysis of Forecast Sharing in the Semiconductor Equipment Supply Chain', *Management Science*, 51(2), pp. 208–220. doi:10.1287/mnsc.1040.0317.

Torres, O.C. and Moran, F.V. (2006) *The Bullwhip Effect in Supply Chains - A review of methods, components and cases*. Palgrave MacMillan.