# SCM Research

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## IPA-Driven Supply Chain Optimization and Control

Sensitivity analysis via ***Infinitesimal Perturbation Analysis*** (***IPA***) is a technique for computing sample-path derivatives (gradients) of performance measures (expectations) with respect to parameters of interest. Because IPA is a sample-path technique, it is entirely non-parametric in the sense that it is broadly valid, regardless of the underlying probability law, is therefore applicable to real-life systems in addition to simulated ones. IPA applications use performance metric gradients in two main ways: to optimize an objective function (typically when designing a new system or improving the design of an extant one), or make dynamic control decisions in a running real-life system.

In the context of supply chain systems, we have used IPA techniques to compute IPA gradient in various systems, including the following:

1. ***Fluid Make-to-stock production-inventory systems with backorders and lost sales*** [1, 2]**.** Here, the product flow is modeled as a ***stochastic fluid model*** (***SFM***), and the gradients are computed with respect to the base-stock level and a parameter of the production rate.
2. ***Fluid (R, r) production-inventory systems*** [3]**.** Here, the product flow is again modeled as an SFM, and the gradients are computed with respect to the upper and lower levels, ***R*** and ***r***.
3. ***Discrete Make-to-stock production-inventory systems with backorders*** [4]**.** Here, the product flow is comprised of discrete transactions, and the gradients are computed with respect to the base-stock level and a parameter of the lead time process.

### Discounted Cost Optimization

Supply chain optimization often involves the selection of parameters that minimize supply chain costs (e.g., holding costs and stockout penalties). Typically, the costs are not discounted to reflect the time opportunity of money. A current research in progress studies a broad class of Make-to-Stock production-inventory systems with continuous replenishment and discrete demand arrivals, where the arrival process is a renewal process. The study derives functional equations for a *discounted* cost function consisting of holding costs and stockout penalties, as function of the initial inventory state, over an infinite time horizon. Analytical and numerical methods are then used to compute the cost function and its gradients with respect to the base-stock level and replenishment rate parameters. These gradients are then used to optimize that cost function with respect to these parameters.

## References

[1] Y. Zhao and B. Melamed, "IPA Derivatives for Make-to-Stock Production-Inventory Systems with Backorders", *Methodology and Computing in Applied Probability*, Vol. 8, No. 2, 191—222, 2006.

[2] Y. Zhao and B. Melamed, “IPA Derivatives for Make-to-Stock Production-Inventory Systems with Lost Sales”, *IEEE Trans. on Automatic Control*, Vol. 52, No. 8, 1491 – 1495, 2007.

[3] Y. Fan, B. Melamed, Y. Zhao and Y. Wardi, “IPA Derivatives for Make-to-Stock Production-Inventory Systems With Backorders Under the (***R***,***r***) Policy”, submitted.

[4] B. Melamed, Y. Fan, Y. Zhao and Y. Wardi, “IPA Derivatives for a Discrete Model of Make-to-Stock Production-Inventory Systems with Backorders”, submitted.