# Chapter 61
# System Dynamics Simulation of a Supply Chain Intelligence Model

**Debasri Dey**
*IGNOU, India*

**D. Sinha**
*IIFT, India*

## ABSTRACT

*Supply chains today are, primarily, measured by Key Performance Indicators (KPIs) such as order-fulfillment, availability to the consumer (percent in-stock) and cost reduction, as well as financial KPIs such as return on investment (ROI), return on brand equity and inventory. These KPIs measure the performance of supply chain as a whole. A supply chain is a network of nodes. The performances of individual nodes are measured with KPIs such as production rate, shipment rate, inventory and the like. These metrics may indicate the performance but may not indicate the cause of such performance. For example, a node whose production rate is below the desired level may be because of poor supply of inputs of production by its supplier node.Thus mere identification of KPIs and their evaluation will not enable to identify the root cause of a problem in a supply chain. Therefore, we need a business intelligence framework that will satisfy the objectives, namely, identification of outcome of each node of the supply chain and its cause. The existing Supply Chain Intelligence (SCI) frameworks aims at identifying metrics that reflect the performance of individual nodes and the total supply chain, but fail to identify the cause of such outcomes. It implies that the linkages or association between the KPIs of individual nodes are required to be identified and defined. In this paper, contingency and systems approach has been used to identify the dimensions of the firm, its internal environment, the complement and the external environment. A system dynamics based approach has been used to identify the causality and resulting behavior of the supply chain. The paper proposes a SCI framework and a System dynamics Model that help in identifying the reasons for supply chin performance and lead to the actions required to be taken for improvement in performance of the supply chain.*

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## INTRODUCTION

Supply chain is a network of nodes that is responsible for providing the time and place utilities to the end customer. The measurement of performance of a supply chain is important from the perspectives of the customer satisfaction, organisation's profitability and stakeholder relationship. According to Chan (2003), performance measurement describes the feedback or information on activities with respect to meeting customer expectations and strategic objectives. It reflects the need for improvement in areas with unsatisfactory performance. Thus efficiency and quality can be improved.

Various metrics of measurement and frameworks are in use for the purpose of measuring performance. Key Performance Indicators (KPIs) such as order-fulfillment, availability to the consumer (percent in-stock) and cost reduction, as well as financial KPIs such as return on investment (ROI), return on brand equity and inventory measure the performance of supply chain as a whole. The KPIs such as production rate, shipment rate, inventory levels, inventory accuracy and the like measure the performance. The magnitude of the measures may indicate the deviations from desired performance levels but may not identify the cause of such performance. For example, a node whose production rate is below the desired level may be because of poor supply of inputs of production by its supplier node. Several appropriate performance metrics and measures of SCM have been identified and discussed by Gunasekaran et al. (2001), and Gunasekaran, Patel, Ronald, and McGaughey (2004). These include order path, reduction of lead-time, quality and the way the information is presented flexibility and other such metrics.

The model suggested by Edward Frazelle (2001) consists of four types of indicators: quality, time, financial, and productivity. To complete the analysis, all indicator types need to be considered, and they need to work together.

*Quality:* These indicators are often the simplest to implement and measure. Typically, they tell how well a supply chain or its constituent is performing a specific activity—a common logistics indicator in this classification is accuracy— including order accuracy, inventory accuracy, picking accuracy, etc.

*Time:* These indicators focus on the time the supply chain or its nodes takes to complete specific activities. They show where saving time during specific activities can improve the overall supply chain performance.

*Financial:* These indicators help managers identify the supply chain cost drivers and help move toward a more efficiently managed supply chain.

*Productivity:* These indicators examine how well resources are used. For example, filling vehicles to their capacity, instead of sending out vehicles half-full, could reduce costs and improve efficiency. Keebler (1999) suggests the qualities to look for in indicators, i.e., it should be quantitative, visible, uses economies of effort, facilitates trust, measures what is required and other similar properties.

However, focusing on only one type of indicator may actually have a negative impact on product availability. For instance, a decision to send vehicles on a distribution run only when they are filled to capacity could cause stock-outs at the next level down unless inventory policies are adjusted to compensate for reducing ad hoc shipments. It is very important to view these indicators holistically—to make sure they are harmonized and not working against each other—and to identify the tradeoffs required to strategically improve overall supply chain performance (USAID, 2010).

The SCOR-model specifies five performance metrics in two categories: customer- facing metrics that include reliability, responsiveness, and flexibility, and the internal-facing metrics that include cost and assets. Each of the performance attributes contains a set of metrics. As an example, the customer facing attribute named Flexibility is measured by the three metrics: Upside Supply Chain Flexibility, Upside