Predictive Metrics for Supply Chains

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Summary: Many supply chain management decisions continue to be made as though driving with the rear-view mirror. This project offers a set of metrics that provide supply chain managers with a forward-looking approach to predict supply chain future performance and align their strategy with performance outcomes.

KEY INSIGHTS
1. Traditional or “reactive” performance metrics measure past performance and can be used, at best, for damage control.
2. Predicting and monitoring a company’s critical success factors allow preventing performance problems before major damage is done.
3. Predictive metrics are customized based on the company objectives and its supplier types.

Introduction
The world economic crisis of 2008 has led several organizations to announce record losses and bankruptcies. But couldn’t the chief factors have been predicted, at least to some extent? What if the critical success factors of a company are predicted and evaluated, wouldn’t that eliminate, or at least cushion, such misfortunes?
Most organizations today use some form of performance management systems. It has been recognized over the past couple decades – especially with the introduction of the “Supply Chain Operations Reference (SCOR) model” and “The Balanced Scorecard” – that metrics beyond the purely financial ones need to be monitored for optimal performance. Nevertheless, metrics continue to focus on reporting past performance instead of providing a forward look toward the future. It is like someone driving using the rear-view mirror instead of the windshield.

In this paper I provide a framework for developing predictive metrics for supply chains. The goal of these metrics is to provide a key set of indicators, aligned with the business strategy, that provide early warnings of problems or early signals of successful project completion. They allow organizations to analyze risks and provide supply chain managers with a forward-looking approach to align their strategy with performance outcomes. My target audience is the Aerospace and Defense (A&D) industry but the results could be expanded across industries.

There is no one-size-fits-all set of predictive metrics. Finding the optimal set depends on the project focus and the type of hired supplier. In this thesis I measure performance in the four areas of cost, schedule, quality and technical. I use system dynamics models and insights from cross-industry experts to develop my framework. I employ three Boeing programs as case-study subjects and illustrate implementation of the framework.

Research Question
This study aims to provide a set of metrics that can be implemented for different production programs in the Aerospace and Defense (A&D) industry to enhance their operation. The objective is to answer the following question:
What set of indicators closely predicts supply chain future performance in the areas of cost, schedule, quality and technical?
The scope is limited to production programs, i.e. no initial developmental stages are considered. In
addition, the study focuses on the manufacturing supply chain of the program and does not include the maintenance one.

Methodology

I used three methods to construct my framework:
1. Data Analysis: to determine data trends and correlations.
2. System Dynamics Modeling: to visualize the structure and dynamics of the studied supply chain and determine the critical factors affecting its performance.
3. Case Studies of three programs of The Boeing Company: to provide multi-perspective analysis and illustrate the application of the predictive metrics framework.

Predicting Supply Chain Performance

I describe six tactics for predicting supply chain performance that guide my search for predictive metrics.

1. Monitoring Sub-tier Supplier Performance
   The contractor is usually primarily focused on monitoring its first-tier suppliers and leaves the responsibility of monitoring the further sub-tiers to them. However, a problem that arises upstream can travel through the entire chain (see Figure 1). So a contractor’s visibility to the performance of its sub-tiers, beyond the first one, can help it predict the performance of its first-tier suppliers.

2. Root Cause Analysis of Supplier Position
   Often suppliers provide signals of a problem waiting to happen. For example, a supplier might suddenly start making early deliveries, or decide to use substitute material or even ask for cash early. This most likely shows that the supplier is in bad financial health which will ultimately have adversarial affects on the contractor’s supply chain.

3. Data Trending
   Supply chain managers typically use dashboards with indicators that change color once performance drops below a certain level for a certain period. Rarely, if ever, do we see dashboards showing data trending. For example, within the shaded regions in Figure 2, a manager believes that the supplier’s performance is going well. Nonetheless, as data trending in the graph shows, the supplier’s performance is expected to drop down into the yellow rating if no preventive action is taken.

4. Statistical Process Control
   Supplier performance exhibits variation. Some variations are just “white-noise” while others have assignable factors. It is critical to differentiate innocuous variations from harmful ones to shape supply chain managers’ decisions.

5. Inspecting Quality of Supplier Orders
   Most companies rank their suppliers based on performance and place them in categories of high or low-performing suppliers. As the percentage of critical orders made to “high-performing” suppliers decrease and that made to “low-performing” suppliers increase, it is likely that more problems are going to emerge along the way.

6. Probing Intrinsic Changes within Supplier
   Intrinsic changes can happen to a supplier’s business which might affect performance. Examples include employee attrition, especially of critical skills, and how training of new employees is accomplished. Other examples include a change in management or a change in processes such as implementing LEAN. Such intrinsic changes, if probed, can predict suppliers’ future performance.

A System Dynamics Approach

I developed four system dynamics models to visualize the structure and dynamics of the supply chain. The models enabled identifying the critical factors affecting the performance of the supply chain in the four areas of: cost, schedule, quality and technical.

Table 1 lists those critical factors. They are grouped by type (people, process, product and business) and the performance areas (cost, schedule, quality, and technical) that they primarily affect are identified.
Program Segmentation: Figure 3 (b) shows Lapide’s “Operational Performance Triangles” whose purpose is to align operational performance to business goals. I used this concept to segment programs by focus: “Customer Response”, “Efficiency” and “Asset Utilization”.

My predictive metrics framework (see Figure 4) identifies different sets of predictive metrics based on the program focus and supplier type.

Comparing Predictive Metrics to “Reactive” Ones

Predictive metrics and historical or “reactive” metrics measure the same things in completely different ways. While “reactive” metrics almost entirely measure what could be measured based on historical data after-the-fact, predictive metrics measure the causal factors leading to performance before-the-fact, or what should be measured (see Table 2).

Table 2: Sample Predictive VS Reactive Metrics

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Predictive Metrics</th>
<th>Reactive Metrics</th>
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<td>Backlog</td>
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<td>Critical Skills per Project</td>
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A Predictive Metrics Framework

For a company to succeed, its business strategy, supply chain and metrics need to be aligned. Consequently, predictive metrics need to be customized per program focus (or company objectives) and supplier type.

Supplier Segmentation: Figure 3 (a) shows Cox’s “Power Matrix” which divides suppliers into four categories based on the buyer-supplier’s relative powers. A program needs to segment its suppliers according to this matrix to determine which set of predictive metrics to use.

Figure 3: (a) Power Matrix (b) Operational Performance Triangle
Adapted from: (a) Cox 2003 (b) Lapide 2006

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Figure 5 shows the concept of operation of my predictive metrics model. Both the program focus and supplier type determine which predictive metrics to use. There’s also the actual supply chain operation which feeds changes to predictive metrics from its current operation. These in turn are fed to the system dynamics model to determine the root cause factors and corrective action. This adjusts the supply chain operation and the loop goes on to keep enhancing performance.

Figure 5: Concept of Operation

Conclusion

Predictive metrics provide early warnings of problems and early indications of successful project completions. They do not eliminate the need for historical data, but provide smarter ways to look at them.

For a company to achieve success, it is imperative that its strategy, supply chain and predictive metrics are aligned. Consequently, predictive metrics are customized based on company objectives and the hired suppliers.