SUPPLY CHAIN MANAGEMENT THROUGH COST MODELING

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ABSTRACT
Demands on the electronics industry for smaller, faster, and cheaper boards have made the supply chain more complex. Outsourcing, new technologies, and increasing performance requirements make designing and building the right product for the right price more difficult than ever.

We will present a framework for understanding and managing the supply chain through cost modeling. Cost models that accurately reflect the cost impact from technology and design decisions enable a more precise understanding of supply chain behavior. Cost models can show the extra cost of adding a layer, the expected savings from relaxing design rules, or the cost of lead free processing compared to non-lead free processing. The models also provide context to understanding the "should cost" of a product and the path to achieving it.

Since the guidance from cost models is based on the true supplier cost drivers and pricing behavior, designer cost reduction efforts will result in higher savings compared to not using the cost models. Without cost models, designers risk missing suppliers real cost drivers and, therefore, the opportunity to decrease cost.

This cost modeling framework allows the designers to realize the lowest cost product by matching the right design with the right supplier. It is a method for understanding a design decisions cost impact: a design change, a supplier change, or even the impact of new technology.

Key words: supply chain, cost model, should cost

INTRODUCTION
Finding the right design for a product early in the design cycle saves money. Redesigns are both expensive and time consuming and may delay the ultimate product release. To avoid these problems, designers have tools to validate the design, electrical performance, thermal performance, etc. In the same way, supply chain cost modeling helps designers evaluate the cost effectiveness of design decisions and find the right design as early as possible.

SUPPLY CHAIN COST MODELING
Definition
Supply chain cost modeling uses cost models to quantify the relative cost impact of design trade-offs and ultimately help designers make better technology trade-off decisions. These models help the designer understand how much more or less it costs to add a substrate layer, or to change the pitch or design rules. The framework has three parts: the cost models, model usage, and feedback. Before exploring the cost models, it's important to understand how the supplier RFQ process usually works.

Price vs. Cost
One company's price is another company's cost. This can make it confusing to talk about "cost models" because it's not always clear whether the supplier or the OEM costs are under discussion.

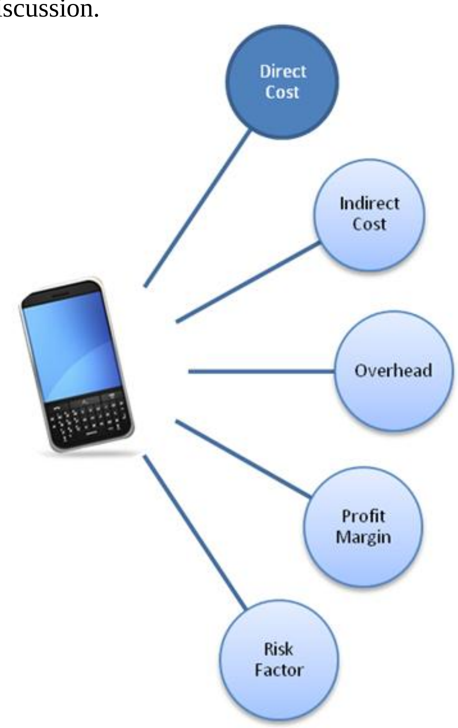

Figure 1. Components of Total Cost

Figure 1 shows all the different "costs" that are factored in to generate a price. Most suppliers calculate their direct costs, distribute overhead and indirect costs, add profit, and sometimes a risk factor to come up with a price.

The models are designed to quantify the suppliers underlying cost drivers – not the actual costs – for design decisions. One of the primary benefits of this approach is to help focus designers on the one area of the many pricing factors that they have complete control over: the design. It's unusual that the OEM would have any control of how a supplier calculates and distributes overhead, their desired profit margins, or their risk factors. But if the design is optimized for a supplier's capabilities, then everyone can benefit because cost is removed from the product rather than simply redistributing existing "profit" which is often what happens in pricing negotiations.

Cost Models

In order for a designer to be able to use cost models for design decisions and technology tradeoffs, the cost models require two key features: relative cost accuracy and real supplier cost drivers.

Relative cost accuracy means the models correctly capture the differences between different design decisions. The models should answer the question "How much more or less expensive is it if my design is X instead of Y?" The model is *not* a replacement for the normal quoting and negotiating process because it does not produce either actual supplier costs or formal quotes. The designer can use the cost models to help create the optimal cost for their design without needing to know what that optimal cost is.

The real supplier cost drivers refers to accurately capturing the way a supplier understands their costs and how they are passed on in the pricing. Of all the factors in Figure 1, most of the cost of the design is captured in either direct or indirect/overhead costs. There is no industry standard for determining which costs are direct and which are allocated. This makes it important to understand which design configurations will actually reduce the board "cost" for each supplier.

This framework only works if these models can incorporate both of these features. A designer can generally reason out whether a specific design decision causes the cost to go up or down. However, it becomes much more difficult when a scenario involves multiple variables, such as shrinking the board, but including more difficult design rules. Is this more or less expensive? That's why it is so important to have a model that can identify the real cost drivers and *quantify* the difference. The designer now has a tool that can help identify the real expected value of their design decisions.

Using the Models

Once the models have been developed, they basically serve as a source of feedback from the supplier to the designer. It's important to understand what the models are and are not in order for anyone to receive any benefit from them.

For the OEM, the model becomes a consistent way to evaluate the cost impact of design decisions. The model provides consistency in evaluating a design's cost effectiveness throughout the entire design cycle. It also allows a better design through rapid feedback very early in the design cycle before a majority of the cost has been committed in a specific configuration. Without the model, each designer would make different decisions based on a different perceived value which can lead to surprises later on.

What the model does not do, is commit the supplier to any particular pricing or reveal any confidential information about the supplier's costs or margins. The models produce accurate relative costs, but this allows all confidential and sensitive data to remain that way while still providing crucial feedback on how designs affect cost. The models are also not designed to be used as negotiation tool to get a better price. The model is fundamentally cooperative and is a vehicle for sharing the best design practices between OEM and supplier.

For the suppliers, the model's benefit is primarily in guiding designers to make better design decisions. If the model is being used as a source of evaluating what design choices are most cost effective, then it also becomes a way for suppliers to provide guidance on which design decisions are best suited for their manufacturing process and capabilities.

Feedback

Once the models are in use, they will require periodic updates. This is especially important with any major technology changes being adopted by either side. By providing the input to create the model, there is an agreement that pricing on different design decisions will be accurate. If subsequent quotes do not seem to follow the relative cost differences originally built, it's reasonable to setup a discussion to find out why and update the models if necessary.

IMPLEMENTATION

Setting up this system can be a challenge. The models are fundamentally a cooperative approach to supply chain management and while they don't require a cooperative relationship between OEM and supplier, it is helpful.

Considering all the natural concerns with confidential and proprietary data, gathering the data is the most challenging part of the process. To a supplier, the initial project can often sound like "Give us your cost data." which will almost always create problems. The question actually being asked is "How much more or less will I pay for this design decision?" This is a reasonable question that can benefit everyone involved. In fact, some of this data is often available somewhere in technology roadmaps, Kaizen events, and even sometimes as part of the normal quoting process. Often times, a third party can help by working directly with the supplier to sanitize any data before passing it on to the OEM so there is no chance of any confidential data being sent to a customer.

Implementation of the models can be approached using commercial modeling software, custom software, in-house tools, or some form of Excel. Regardless of the platform used an activity-based approach usually works best because the models have to consider the effects of many different design parameters which can be difficult to capture in other approaches.

Activity Based Cost Modeling

Activity based cost modeling and parametric cost modeling are the two dominant cost modeling methods. Parametric cost modeling is done by statistically analyzing a large number of actual results and creating a model to match those results as closely as possible. This backward looking "black box" approach is appropriate for modeling processes that change slowly over time or cannot be decomposed into individual activities.

On the other hand, activity based cost modeling is the most accurate cost modeling method for forward looking technology tradeoffs because individual activities are characterized and analyzed. This is especially true for new technology where there is no history of pricing from which to derive a parametric model.

In activity based modeling, the total cost of any manufacturing process is calculated by dividing the manufacturing process into a series of activities and totaling the cost of each activity. The cost of each activity is determined by analyzing the following attributes:

- The time required to complete the activity
- The amount of labor dedicated to the activity
- The cost of material required to perform that activity – both consumable and permanent material
- Any tooling cost
- The depreciation cost of the equipment required to perform the activity
- The yield loss associated with the activity

Regardless of the implementation method selected for the model, an activity-based approach generally produces the best results. Because of confidential data concerns between the OEM and supplier, it's almost always impossible to actually construct a complete detailed activity based model this way. However, the approach is fundamentally working from the cost drivers forward, instead of working from past behavior and trying to infer the cost drivers. Just the process of having these discussions is often beneficial.

DESIGN TRADE-OFF EXAMPLE

Let's assume a fairly average mobile phone board – 3-2-3 and 2" by 2.5" - is being designed. The trade-off the designer is considering is increasing the substrate layer count but shrinking the board size. A new 4-2-4 board will have a more expensive substrate with a lower yield, but depending on how many additional boards fit on the panel, the trade-off may or may not make sense. We constructed this scenario using some generic fabrication activity based models and generated the results in Table 1.

	Original Design	Alternative
Structure	3-2-3	4-2-4
Body Size	2.0" x 2.5"	1.9" x 2.0"
Yield	85%	82%
Boards Per Panel	64	88
Panel Cost	\$321.41	\$418.47
Board Cost	\$5.022	\$4.755

* Results are hypothetical

Table 1. Trade-Off Results

The results show the increased boards per panel offsets the increase cost of the panel to produce a net savings of about 30 cents per board. This table should also explain why it is so important to have a cost model that can quantify all these up and down changes: What happens if the yield is even less? Or the board can only be shrunk to 2.2" x 2.1"? All of these may change this trade-off result.

This example was based on a generic fabrication process. Consider now adding the different characteristics or pricing behavior for different suppliers on just this one trade-off. What if a supplier may achieve a higher yield but has a higher labor rate? What if a supplier has tooling to support a non-standard panel size? What if there is only 1 qualified designer with the capability to do this?

With the models as discussed, a designer could quickly generate something like Table 2. This would show how many different designs, including assembly and fabrication decisions, behave across all the company's suppliers. This would enable the designer to make much more informed decisions about the value of all the possible designs.

	Original Design	Alternative 1 @ Supplier A	Alternative 1 @ Supplier B	Alternative 2 @ Supplier A
Structure	3-2-3	4-2-4	4-2-4	2-2-2
Body Size	2.0" x 2.5"	1.9" x 2.0"	1.9" x 2.0"	2.8" x 2.3"
Yield	85%	82%	78%	90%
Board Cost	**Baseline**	**-5%**	**-2%**	**+1%**

* Results are hypothetical

Table 2. Results for a suite of suppliers

SHOULD COST

A natural extension of the models is to help identify a should-cost or target cost. The concept of should cost is usually not well-defined and therefore can cause a lot of confusion. When talking about a "should cost" we recommend discussing ranges, not values, and including should cost conditions. So the question becomes "What is the should cost given all possible PCB suppliers?" or "What is the should cost in my industry?"

Given an identical design, yield, supplier capability, and profit margins, if asked to share what the cost of the design is, two suppliers will always produce different costs. Variations in what activities are charged directly and accounting practices in applying overhead, mean there is no "should cost" for a design. Instead, it's valuable to find a should cost range that can include the normal amount of expected variation that results from normal demand issues, risk assessment, material price fluctuations, and all the other things that influence pricing.

To determine should cost, there needs to be scope that includes the range of possible suppliers and often a time frame. The question of how much should a product cost today is very different from how much a product should cost in two years considering possible technology changes.

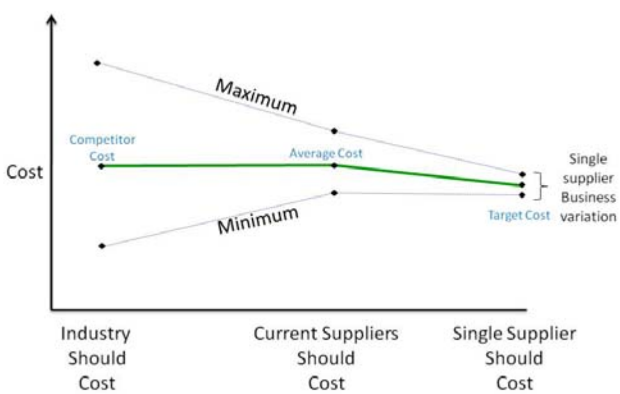

Figure 2. Levels of Should Cost

Figure 2 shows three levels of should cost. First is the should cost range for all possible industry suppliers. This range is very wide because it includes a huge variety of suppliers that compute costs in many different ways. In addition, it includes costs for designs that may not be similar to the types of designs or volumes in an OEM's normal business. Next, the should cost scope is narrowed to only include suppliers that are in some way more similar to a supplier's current business – perhaps all currently approved suppliers. Finally, a designer can identify a should cost based on a single supplier.

The models are an ideal foundation for this type of exercise. Instead of basing the actual model values on a specific supplier feedback, results from a benchmark, industry best practices, or estimates from industry experts can be used. The real benefit in approaching should cost this way is that discussion around the targets or paths to achieving them can center on the state of specific activities or the cost of specific design features. The discussion is naturally moved into specifics rather than a discussion of whether the overall target number is right.

CONCLUSION

Supply chain cost modeling enables designers to realize the lowest cost product by matching the right design with the right supplier. Cost models that accurately reflect differences and the underlying supplier cost drivers enable better decisions early in the design process.

These cost models have the following three major benefits to reduce product cost.

1. Designers make better decisions about technology and design characteristics.
2. Suppliers influence early design choices to match their core competencies and abilities.
3. "Should Cost" models throughout the design process insure there are no cost surprises at the end of the design cycle.