



The Anatomy of Product Cost

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This paper will outline what makes up product costs today and why having a better understanding of the True Economic Cost of a product will measurably benefit manufacturing organizations.

A Tale of Three Costs

The vice president of product development meets with three of his most talented and trusted employees:

- The company's most senior engineer, a grizzled designer who knows more about the company and its product than anyone else;
- The hot-shot new hire, complete with a fancy degree specializing in computer simulation and modeling; and,
- The controller of the division.

The vice president says to them, "I have a very important question to answer and I need your opinions: What is two plus two?"

The senior engineer begins to stare at the ceiling, scratching his chin while muttering, "Well, two plus two is usually four...typically...yes...at least it was back in '78. But, of course you need to factor in safety...and there could be problems...FIVE! Let's call it five."... and walks out of the room.

After a two-week, 10,000-line simulation with the latest custom modeling suite, the new hire returned to the VP's office with a complex slide presentation complete with stress strain color contours, signal to noise plots, and stochastic Monte Carlo diagrams. "So, you see, Sir, the answer to the question is without question 4.00000000007...times 1025."

The controller never answers the question. After a few weeks, the VP called him and said, "You never got back to me on that answer. I need an answer. What is two plus two?"

The controller paused for a moment and then replied, "What do you want it to be, Boss?"

Introduction

The joke above is a lighthearted commentary on the nature of the man-made concepts of cost and cost accounting. This paper will outline what makes up product costs today and why having a better understanding of the True Economic Cost of a product will measurably benefit manufacturing organizations.

Some of the factors that determine the True Economic Cost of a product include: design cost drivers, manufacturing cost drivers, marketing cost drivers, and supply chain / purchasing cost drivers.

True Economic Cost

Manufacturing a component requires tangible physical resources — the material mass, the labor time, time on machines, life of tools, machines, factories, energy, shipping, warehousing costs, and a whole lot more. The fair-market economic cost of these resources, in a truly efficient market, with zero mark-up at any point in the supplier chain is the True Economic Cost of manufacturing the item. Some of the factors that determine the True Economic Cost of a product include:

- **Design Cost Drivers** — A product’s design greatly affects how much it will cost to produce. The geometry of the part, material selections, tolerances, surface finishes, and a number of other attributes determine what processes will be used in manufacturing.
- **Manufacturing Cost Drivers** — The capabilities of a given factory — including process routings, tooling, speeds and feeds, and batch sizes — affect a product’s True Economic Cost.
- **Marketing Cost Drivers** — The annual production of a product and the life of the product line can have a powerful effect on the manufacturing processes used, suppliers selected, and whether to use capital investment to reduce the variable costs of production.
- **Supply Chain / Purchasing Cost Drivers** — The supply chain set up by the purchasing group, including interplant logistics, affects product costs.

Notice that there has been no mention of “accounting” or “costing” methods, yet. The cost drivers described thus far affect only the economic resources required to make a product. Accounting is a man-made field that attempts to translate these economic resources into a common language (dollars). Accounting assigns or “allocates” costs that are hard to disaggregate from large expense “pools” to an individual component.

True Economic Cost is represented as the first bar in Figure 1.

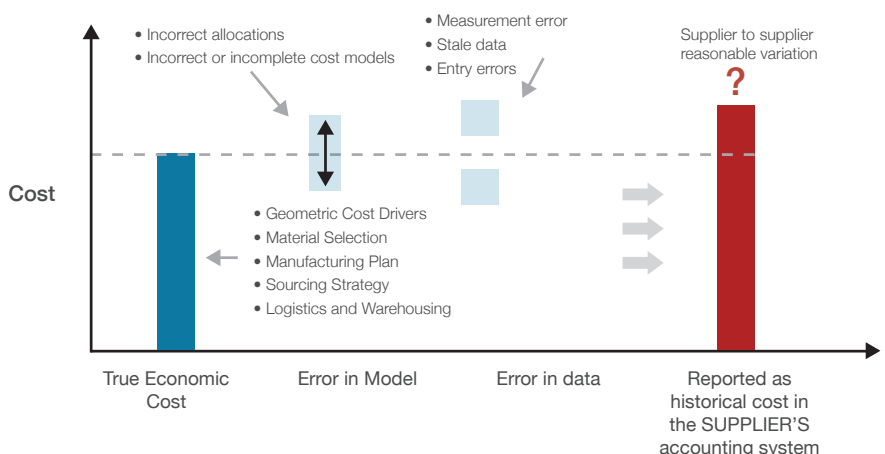


Figure 1. Getting from True Economic Cost to the Factory Door

Cost estimates are often calculated using out-of-date information and therefore do not reflect True Economic Cost.

From the Truth to the Factory Door

In the real world, precise measurements for physical resources are difficult to obtain. As a result, companies develop a variety of models that attempt to estimate the amount of resources consumed for a given part or product based on the total amount of resources used in a given time frame. But these models are imperfect, and they result in a band of uncertainty around the True Economic Cost. How much uncertainty? Most cost experts believe it ranges from plus or minus 5 to 15 percent of the True Economic Cost. However, if an organization could get precise measurements of physical resources consumed and compare them with the results of their expert estimates, they would find that the variance would be more significant — somewhere between plus or minus 20 to 30 percent.

In addition to the basic modeling of costs and resources, there are also allocations for indirect overheads, which are perfectly allocated in True Economic Cost, but are not very certain in the real world. The main goal of the popular accounting method, Activity Based Costing, is to allocate indirect overhead in a more accurate way. These ideas are represented by the second bar in Figure 1.

Further confounding the cost is the reality that models require a certain level of basic data to operate. This data comes in a variety of forms including material rates, labor rates, overhead rates, speeds and feeds, and more. While the quality of this data is usually more certain than the models and estimates that use them, the data can become stale fairly quickly. As a result, cost estimates are calculated using out-of-date information and therefore do not reflect True Economic Cost. This degree of uncertainty is displayed in the third column of Figure 1. In aPriori's experience, 5% to 10% of data has significant staleness problems or errors in calculations. Modern ERP systems help with this problem, but cannot completely prevent the staleness. ERP has helped prevent out of date data by providing a 'single source of truth'. However, if input data to ERP is stale, any system will calculate incorrectly.

The cost at the factory dock (in an internal factory without complex transfer pricing) is presumed to be within the combined uncertainty. For the sake of argument, the fourth bar with the question mark above it represents the cost carried in the factory's accounting system or the supplier's system.

Supply Chains & Cost

Buying components from suppliers adds another level of complexity to the cost of a product. It's reasonable to expect that a supplier will want a profit on the manufacture of a component. Assuming an economically efficient market where there are many supplier alternatives, there would be an efficient market mark-up the average supplier would expect to be paid.

No cost model or accounting system can predict or account for the random effects of commercial cost drivers on estimates.

This mark-up is represented in the second bar of Figure 2.

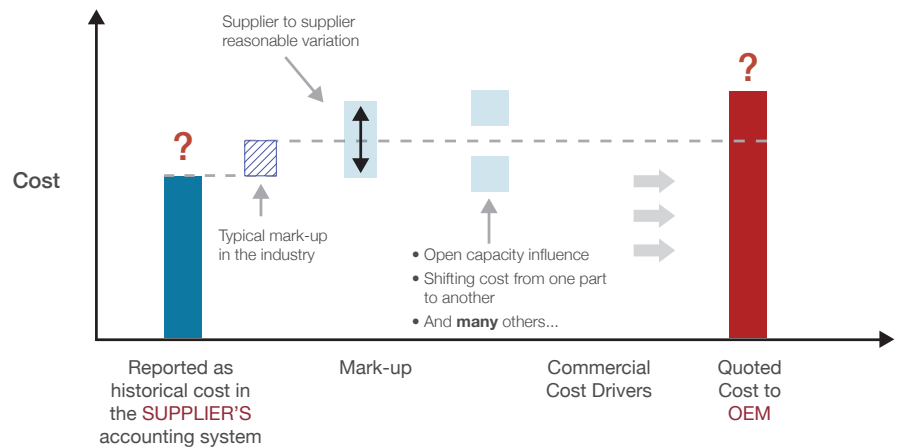


Figure 2. How Cost or Price Changes from Supplier to Customer

But, in the real world, suppliers have different business models that result in a reasonable supplier to supplier variation in the mark-up. And, beyond this reasonable variation, there are also “commercial” cost drivers to consider. These are commercial situations that are almost impossible to predict. Some examples include:

- **Too much capacity** — The supplier has ideal assets and needs to fill the factory with work to cover fixed costs. As a result, they lower their price.
- **Not enough capacity** — The supplier has too much work and charges a large penalty for interrupting their schedule.
- **Loss leaders** — The supplier is trying to “buy” new business, so they play a shell game where they include part of the True Economic Cost and efficient market mark-up from one part to another to make a particular part of interest look cheaper in order to win business.
- **Relationship effect** — The supplier quotes or the customer accepts a price outside of the range of a rational buyer, based on a personal or corporate relationship.

The effects of commercial cost drivers are significant – typically much bigger than the reasonable variable in mark-up and many times greater in variation than the magnitude of the efficient market mark-up itself. No cost model or accounting system can predict or account for the commercial cost drivers. They are random in nature.

Adding the efficient market mark-up, reasonable market variation, and the variance from commercial cost drivers to the cost the supplier carries in their accounting system, we arrive at the right-most bar in Figure 2.

As the cost variance stacks up, companies move further away from True Economic Cost.

Cost Variance Stack-up

Figure 3 combines the cost variances from internal and supplier sources (Figures 1 and 2). Note that the stable and invariant parts of the cost are the True Economic Cost and the efficient market mark-up. All the other variances add or subtract from the sum of the invariant components (True Economic Cost and typical mark-up). Furthermore, each variance type is additive to the others, starting with the left-most bar and resulting in to the right-most bar in Figure 3.

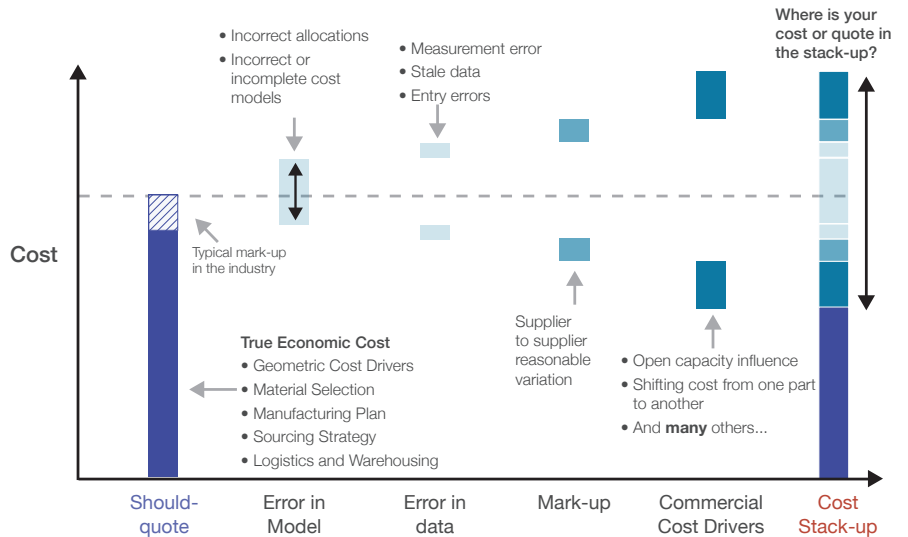


Figure 3. Cost Variance Stack-up

The True Economic Cost is shown by the first bar in Figure 3, but the price carried in the ERP system at the supplier's customer can be anywhere within the large band shown in the last bar in Figure 3. Note that the range of the variance is significant and can almost overshadow the effect of the True Economic Cost. One could actually measure how much of this cost confusion occurs by applying the electrical engineering concept of signal to noise ratio.

While the two plus two story at the beginning of this paper is an exaggeration, its lesson is important. And, the real-world example discussed thus far only demonstrates cost confusion present in a supply chain one level deep. Adding layers to a supply chain further increases the cost variance.

A Real-Life Case Study in Quote Variation

To further exemplify the costing challenge, consider the following real-world data: Using a popular online manufacturing work bid web site, a product company requested a quote for a very simple turned part. Within a week, the buyer received 18 quotes for the part. The part and the bidding results are displayed in Figure 4.

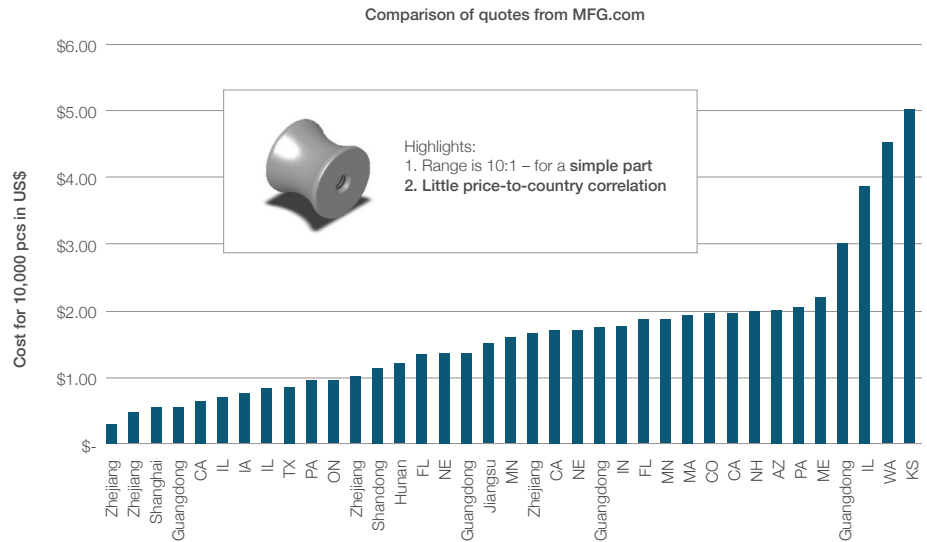


Figure 4. Quotes on a Simple Turned Part

Notice that the range of bids from highest to lowest is 10x. It is also interesting that geography had little effect on the size of the quote; a number of US suppliers quoted significantly less than some suppliers in China. Why did this happen? A portion of the cost could be from added shipping cost, but most likely this was probably due to the massive impact of commercial cost drivers.

In discussions with suppliers, the buyer also noted that the price would decrease based on the number of times he spoke to the supplier. These discussions were not formal negotiations — just a series of questions around how the part would be made and the suppliers’ capabilities. So obviously, the commercial cost driver of the relationship was active here.

The 10x range could also be a result of the low volume run on the part. However, similar cases with higher volumes of production typically result in quotes with ranges of two to three times. Figure 5 outlines two additional examples from real product companies. The first part received five quotes and the second part received four. The variable or “piece part” costs, the upfront capital tooling, and the fully amortized costs of the part are shown. Note the tremendous level of variability in the quotes, which can be measured in several different ways.

Cost Metric	Quote 1	Quote 2	Quote 3	Quote 4	Quote 5	Median	Standard Deviation	Max / Min Range	(Max Quote) / (Min)	Range as % of Median Quote	(Std. Dev) / (Median), i.e. Noise/Signal
Complex Die Casting with Machining 1											
Variable Cost	\$ 6.90	\$ 18.10	\$ 18.10	\$ 22.40	\$ 30.10	\$ 18.10	\$ 8.41	\$ 23.20	4.4	128%	36%
Capital Investment	\$ 131,300	\$ 77,610	\$ 148,275	\$ 101,000	\$ 99,000	\$ 101,000	\$ 28,105	\$ 70,665	1.9	70%	40%
Fully Burdened Cost	\$ 9.47	\$ 19.60	\$ 21.00	\$ 24.30	\$ 32.00	\$ 21.00	\$ 8.16	\$ 22.53	3.4	107%	36%
Complex Die Casting with Machining 2											
Variable Cost	\$ 17.30	\$ 37.30	\$ 14.80	\$ 8.00	n/a	\$ 16.05	\$ 12.60	\$ 29.30	4.7	183%	43%
Capital Investment	\$ 103,800	\$ 72,000	\$ 102,000	\$ -	n/a	\$ 87,000	\$ 48,543	\$ 103,800	1.4	119%	47%
Fully Burdened Cost	\$ 18.10	\$ 37.90	\$ 15.60	\$ 8.00	n/a	\$ 16.85	\$ 12.75	\$ 29.90	4.7	177%	43%

Levels of variation in the quote are huge compared to the magnitude of the quote itself

Figure 5. Quote Data for Two Machine Die Castings

Manufacturers in need of a way to calculate True Economic Cost are turning to software tools that leverage physics-based mechanistic cost models.

Shift in Focus: From “Number in the Box” to True Economic Cost

The previous discussion creates a number of questions. Why do organizations focus on absolute cost numbers in early cost assessments when this historical cost or price is so variable? Furthermore, what good is it to reduce cost when the cost signal to noise ratio may be low? How does a company know if it is reducing cost when the noise could overshadow the gains?

The answer is that cost reduction is about relative changes in cost, not absolute changes. This means that manufacturers need a high fidelity way to calculate True Economic Cost. Physical resources expended are the key – there will always be noise and there will always be commercial cost drivers. Organizations looking to employ high fidelity models of True Economic Cost are turning to a Product Cost Management software with built-in, physics-based mechanistic cost models. This new approach to understanding cost and enacting cost reduction simply removes a great deal of the uncontrollable variance and focuses on the physical reality of what the company is doing.

The next logical question is how can companies tell if their design, manufacturing, purchasing, and marketing decisions are reducing or increasing costs if there is so much variance in an absolute cost or price number? The answer is they can not — not on an individual part level. However, products tend to contain many parts. Furthermore, there is no indication that the variance in the cost estimate changes in a systematic way depending on design, manufacturing, and sourcing choices. Therefore, the effects of these noise factors on absolute cost cancel each other on average when considering the roll-up of costs at a bill-of-materials level. Put another way, if companies believe they have reduced the True Economic Cost by 10 percent on average, it is very likely that the cost of the whole product will decrease by 10 percent as well.

Embrace the fact that you probably are not paying what you should and engage the supplier or your own plant to explain HOW they arrived at their numbers. It will be a learning experience to help improve your mechanistic cost models.

So what does this all mean to you?

- **Stop Focusing on the Noise (Historical Cost)** — Manufacturers need to stop trying to model random noise, like historical supplier prices and factory costs, in their product cost management efforts.
- **Start Focusing on the Signal (True Economic Cost)** — How do you do this? There are several enablers. First, start measuring real things, not cost. For example, a large part of the Six Sigma methodology focuses on just being able to measure what is occurring. The same is true with product cost management. If you can provide actual, certified measurements of time, mass, etc., this is far more useful than historical costs or price. Unlike the random nature of commercial cost drivers, focus on the repeatable, consistent, and understandable response of a mechanistic cost model to design, manufacturing, purchasing, and marketing cost drivers.
- **Compare and Certify Trends and Order of Magnitude, not Absolutes** — As discussed, there is too much noise in historical numbers for them to be precisely useful in certifying that your process or cost system is correct. So are historical numbers useless? No, they are useful, but for making sure that cost results from a model show the same trend as the historical numbers; the models calculate costs (high to low) in roughly the same order; and, that the order of magnitude of cost results is the same as the historical results. If a company asks for quotes on ten designs and none of the quotes matches the company cost model's results, that's not particularly concerning. If the ratio of the costs for each of the ten parts from the model is not similar to the supplier quotes, there may be cause for concern.
- **Realize that What You Do Pay is Not What You Should Pay** — A natural corollary to the points above is that you should not be terribly disturbed if your Product Cost Management system has cost models that produce results that are sensitive to real cost drivers, but do not match the quote you see or the price you pay. Embrace the fact that you probably are not paying what you should, whether you are paying too much or too little. It is better to engage the supplier or your own plant and have them explain HOW they arrived at their numbers. It will be a learning experience to help improve your mechanistic cost models if the historical numbers are right. If not, you have an opportunity to save money and increase profit. Realize also that your supplier may be just as unaware of the noise in his quotes as you are.



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aPriori software and services generate hard-dollar product cost savings for discrete manufacturing organizations. Using aPriori's real-time product cost assessments, employees in sourcing, manufacturing and design engineering make more-informed decisions that drive costs out of products pre- and post-production. With aPriori, manufacturers launch products at cost targets, maximize savings in re-work projects and avoid overpaying for sourced parts.