The Opportunity Costs of Poor Quality

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Summary

Cost discussions abound in the literature on quality improvement, yet the focus was rarely set on opportunity costs, a rather important economic concept. Only a few articles demonstrate how companies incur these costs when dealing with quality problems. We want to develop a simple 'opportunity costs perspective' to classify costs of poor quality and to show how these have an impact on the bottom line. Applying this perspective might help in explaining why quality improvement and prevention are in most cases profitable investments. It also highlights the fact that traditional accounting for the costs of poor quality might miss important points for deciding on the attractiveness of quality improvement projects. Copyright © 2005 John Wiley & Sons, Ltd.

Key Words: economic assessment of quality; quality improvement; profitability; production efficiency

Missed Opportunities

It is a basic characteristic of our modern times: the world around us is full of options, and we constantly have to make choices of action. When a company has different alternatives to act in a certain situation, preferring one alternative to the other means that a potentially more valuable alternative is not conducted. The difference between the profit of a chosen project – for instance a new drug development project (see Definition Box) – and the potential profit of a rejected alternative constitutes the opportunity costs of doing what we do. If the rejected project would have gained 2 million USD more in profits, we forego the opportunity to increase our bottom line by this amount. The 2 million USD are the opportunity costs of our choice of action.

The same logic of 'missed opportunities' applies to production schedules. Anything that makes a company deviate from its planned activities incurs opportunity costs [1]. Poor quality is a deviation from the plan to run an efficient production system that produces only sellable output. Opportunity costs exist because a poor quality producer has to deal with defective products – the company cannot spend all the time and resources for value-adding activities. Hence, the manufacturer misses opportunities to produce and sell good output, thereby foregoing profits.

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> Opportunity Costs
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> Opportunity Costs are 'costs in terms of foregone alternatives,' see for instance www.hyperdictionary.com/search.aspx?-define=opportunity+cost. Whenever we chose one thing over another, our choice might turn out to be less profitable than the other would have been. Consider the common practice in our industry: whenever we pick a new drug development project, we neglect another – which might have become a great blockbuster. Opportunity costs are in most cases hard to quantify since the development of certain alternatives is not foreseeable. Yet we will show that opportunity costs related to quality problems are very well quantifiable – since the alternatives in this case are clear.

Often, the value of lost opportunities is not included in traditional accounting, since the true cost development for different alternatives seems to be unpredictable at the moment of decision-making. Nonetheless, quality improvements can directly be linked to increasing sellable volumes via reductions in the defect rate [2]. Given that the market allows for growing sales volumes, this has measurable and predictable profit implications. But even without growing sales volumes, the cost burden on the single product, which will be in the core of our argument in this article, can be reduced. Therefore, opportunity costs have a 'real' impact.

As an example, consider a tablet production system that is designed to produce 1 000 000 tablets per period, assuming that all of this output could potentially be sold. A defect rate of 18% means that only 820 000 'good' tablets are produced and the opportunity to sell 180 000 more is foregone. This has quantifiable effects on the two most important measures of production efficiency: productivity and capacity. In what follows, we want to examine these two measures more closely.

The Productivity Effect of Quality

Productivity is a measure for the output that a production process can generate given a certain amount of variable inputs. This relation is commonly depicted in a production function: the maximum possible output a company can manufacture from a given level of variable inputs constitutes a point on this function. Figure 1 depicts a production function t_1, which stands for a poor quality process, and t_2, which is the same process after the quality problem has been eliminated. The result of this improvement is an upward shift, visualized by the arrow between the two functions. The production function t_2 relates higher levels of output to any given input level than t_1. At input level i, for example, the output that can be produced by the improved process is o_2, whereas the non-improved process only yields o_1. The difference between o_2 and o_1, Δo, is the additional sellable output that can directly be credited to the quality improvement. In our previous example, o_2 was 1 000 000 tablets, o_1 820 000 tablets, and the productivity gain Δo was 180 000 tablets.

The logic behind this upward shift in the production function is as follows: because quality problems are now eliminated, the utilization of input factors is more efficient. The waste of inputs on products that cannot be sold is sharply reduced, such that the same total input volume now yields a higher number of sellable products. In other words, the sellable output is increased without increasing the input.

Quality improvements can greatly boost productivity, since a higher percentage of the variable inputs can be transformed into output. An additional benefit is that new technologies, found as a remedy for the quality problem, might use less inputs than the old production

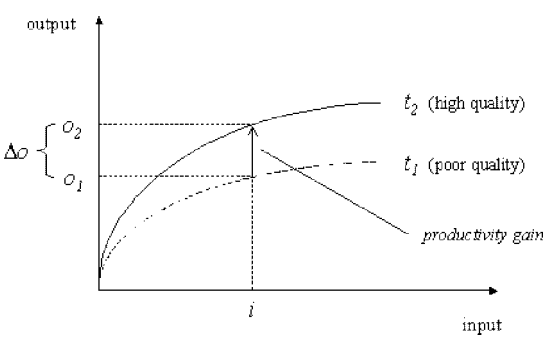

Figure 1. The productivity effect of quality

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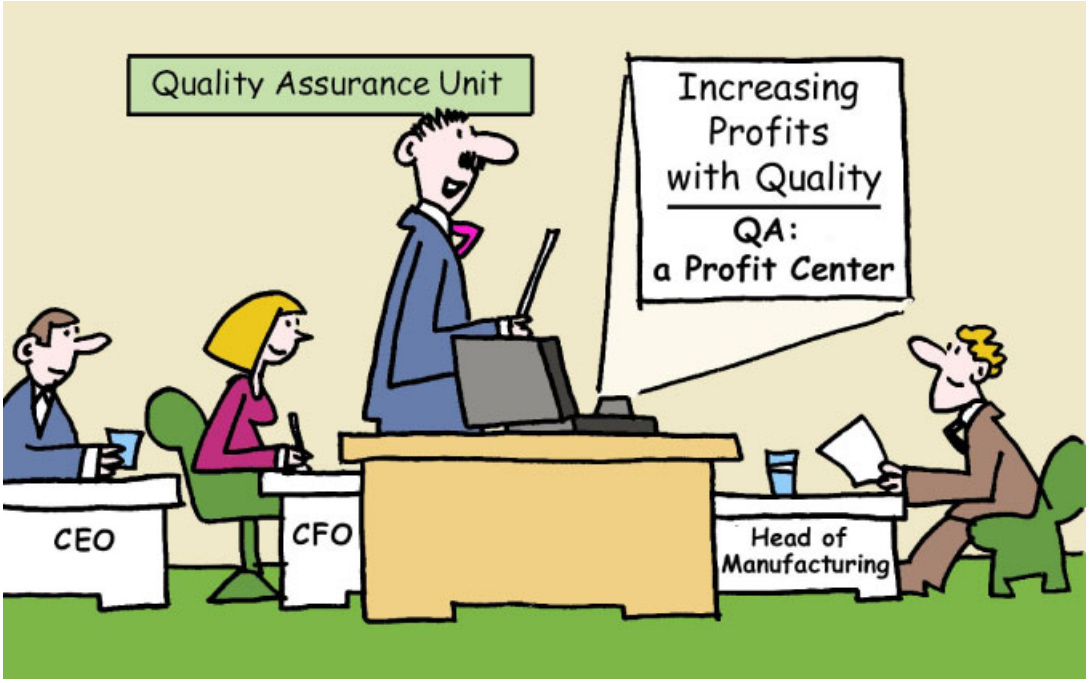

technology. The variable inputs per product might thereby be further reducible, which would lead to an additional upward shift of the production function.

To illustrate the productivity effect of quality, consider that our drug producer has regular variable costs of 5 USD per tablet and a production volume of 1 000 000 tablets per year. Because of an 18% defect rate, only 820 000 instead of 1 000 000 tablets are of sellable quality. Although the inputs have cost the company 5 000 000 USD, the output is less than the originally planned-for 1 000 000 tablets. The costs for a 'good' tablet have increased to 6.10 USD since it has to bear its part of the costs for the wasted inputs. This has made the single tablet 1.10 USD, or 22%, more expensive than originally planned.

Example 1	
Total production volume:	1 000 000 tablets
Defect rate:	18%
Variable production costs per tablet:	5.00 USD
Variable production costs per 1 000 000 tablets:	5 000 000.00 USD
Unsellable quantity because of poor quality: 1 000 000 tablets × 0.18 =	180 000 tablets
Sellable quantity of 'good' tablets: 1 000 000 tablets × (1−0.18) =	820 000 tablets
Variable production costs per tablet for a defect rate of 18%: 5 000 000.00 USD: 820 000 tablets =	6.10 USD
Increase in variable production costs per tablet for a defect rate of 18%: (6.10 USD: 5.00 USD)−1 =	22%

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Which are the opportunity costs stemming from the productivity effect? Broken down to the single unit, the opportunity to produce the tablet at its regular variable costs is forgone when the production is ridden by quality problems. Given that the company operates in a competitive environment and is unable to increase the price to cover this production cost increase, the contribution margin for the single product decreases. In other words, the profit margin per tablet is reduced.

The Capacity Effect of Quality

Poor quality furthermore means that the planned-for capacity is not utilized efficiently. This second efficiency measure concerns the allocation of fixed production costs to the single unit. Fixed production costs mainly exist in form of the production facilities and management overhead. Both make up the most important 'block' of costs that are independent of the produced volume. We can think of them as being our basic 'production capacity': machines and space are as important for the manufacturing of products as is management for the co-ordination of the complex and interlinked processes.

This installed production capacity is often not used efficiently, as numerous examples of overcapacity in modern-day industries show. Besides the traditional triggers for overcapacity such as falling demand or exaggerated industry expectations [3], poor quality might be an even more important factor. The reason for quality-induced overcapacity is the inability to produce a planned-for volume of sellable output while quality problems cause production distortions: the existing capacity cannot be fully utilized when process steps are congested with faulty products and when the production has to be stopped for the elimination of quality problems.

Also management is constrained by dealing with quality problems. A larger proportion of the available management time has to be spent on planning and co-ordinating the efforts to deal with the quality problem, and time reserved for true strategic purposes might decrease. Dealing with operational problems, management involvement lacks on other, maybe more important front lines. As a result of quality improvements, the utilization of the production capacity becomes more efficient since the lines no longer process faulty products and management is freed from firefighting.

Given that the potential sales volume is the same for a high and a poor quality producer, the capacity of the latter has to be larger to produce the same amount of sellable output. We will call this additionally needed capacity to produce the same amount of output 'excess capacity'. It is overcapacity in the sense that the total capacity is inefficiently utilized, but differs from the classical notion since it is still needed to produce a certain sellable output volume. There is no 'free' capacity to be used for volume expansion, since every bit of it is needed to yield the targeted sellable output volume.

Economists traditionally assume that the production capacity cannot be increased in the short run [4]. However, in the long run additional capacity can be built up when the market provides opportunities for increasing sales. For instance, a new assembly line might be added to the existing facilities when demand grows. This capacity extension is associated with additional fixed costs.

Let us say that for a capacity extension above the capacity o, a poor quality company has to increase its fixed costs from f_1 to f_2. The difference between the two fixed cost levels, Δf, is the additional investment needed for this extension. In Figure 2, the fixed cost function c_1 therefore shows an upward shift at

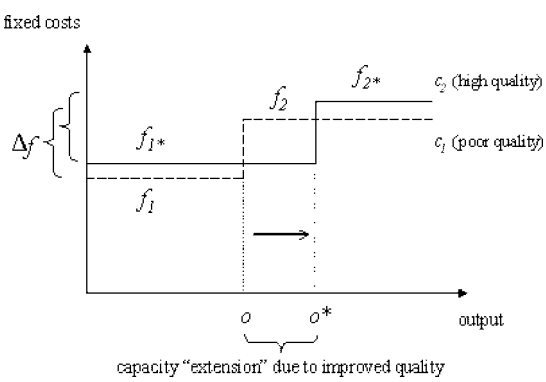

Figure 2. The capacity effect of quality

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capacity level o. If we assume that the company could alternatively improve its quality, the effect of this improvement could be depicted as a rightward shift of the fixed cost function, now yielding c_2. The slightly higher initial fixed costs (f_{1*}) are due to an up-front investment in good quality. One return on this investment is the ability to utilize the existing capacity more efficiently: by freeing up congested capacity, the company can delay an investment in capacity extension up to an output level o^*, which is far greater than o.

Let us take a look at the output range between o and o^*. If a company could sell output in this range and remains at a poor quality level, it has to either sacrifice all potential sales above its capacity limit o, or extend its capacity to keep up with demand. In the latter case, it will then have much higher fixed costs compared to a high quality producer, who is not compelled to invest in new capacity. A defect-free production can serve the market up to o^*. Thereby, high additional costs can be saved. Conversely, the unit fixed cost burden can be contained at a low level.

The capacity effect of quality signifies that the unit fixed cost burden is low when the quality level is high. It can furthermore teach us some lessons about the advantageousness of a continuous high-quality strategy. For this, we have to take a look at a strategy's long-term implications. Imagine that two manufacturers, who initially had the same high quality level and identical production capacities, developed different strategies to deal with quality deterioration. *A* improved the quality whenever quality problems surfaced and invested in prevention, whereas *B* neglected quality investments altogether. For an equal individual demand for both companies, *B* had to increase his production capacity along with the deterioration of his production quality to be able to serve demand. Building up excess capacity is thus a method to 'avoid' quality improvements. Yet it is a fairly expensive method. A quality improvement, especially when the surfacing quality problem is not yet severe, might be a far cheaper way of gaining the needed capacity to fulfill the market demand.

Consider now the case that *A* came from a poor quality background with a lot of excess capacity, while quality improvements subsequently made the use of the extensive production lines more efficient. Excess capacity would thereby be transformed into overcapacity. Although the additional free capacity might be used as a competitive weapon in enabling *A* to quickly accommodate peaks in demand, the total capacity would again be utilized inefficiently – the common case of overcapacity. Thus we find a strong argument for continuously keeping processes in control, instead of letting quality deteriorate. The benefit is that the build-up of excess capacity is avoided, and with it all forms of inefficiently used capacity.

To illustrate the capacity effect of quality, let us again take the above example of a drug manufacturer with a production volume of 1 000 000 tablets and with regular fixed costs of 1 500 000 USD per year. When the production process has a defect rate of 18%, only 820 000 tablets are sellable, which then have to bear the total fixed costs. Similar to the logic of the productivity effect, this increases the unit cost burden by 22%, from USD 1.5 to USD 1.83. The opportunity to produce a tablet at its regular fixed cost burden is forgone. Again, the profit margin per tablet is reduced.

More Opportunity Costs

In our examples, both productivity and capacity effect yielded a 22% difference in the unit costs between high and poor quality producer – in effect, poor quality blurs the distinction between variable and fixed costs, since all inputs can be regarded as a 'fixed' entity needed to produce a however strongly reduced volume. Can we therefore conclude that the total opportunity costs for the poor quality manufacturer are a profit reduction equal to 22% of the production costs?

These costs, which we may call production-related opportunity costs, are only a fraction of the total opportunity costs. We have to consider

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Example 2	
Total production volume:	1 000 000 tablets
Defect rate:	18%
Regular fixed costs per tablet:	1.50 USD
Regular fixed costs per 1 000 000 tablets:	1 500 000.00 USD
Unsellable quantity because of poor quality:	180 000 tablets
Sellable quantity of 'good' tablets:	820 000 tablets
Regular fixed cost per tablet for a defect rate of 18%: 1 500 000.00 USD : 820 000 tablets =	1.83 USD
Increase in fixed production cost per tablet for a defect rate of 18%: (1.83 USD : 1.50 USD) – 1 =	22%

that the poor quality producer only produces 820 000 tablets in output, such that the company forgoes the opportunity to sell 1 000 000. This does not only mean an increase in the cost burden per 'good' product, but also a decrease in sales and thus in total profit. Imagine for instance that a high-quality manufacturer has a profit margin of 4.00 USD per tablet. We already discussed that this margin is lower for a poor quality manufacturer, in our example 2.57 USD. This is equal to a profit reduction of 1 430 000 USD. Yet the poor quality producer furthermore loses the chance of selling the 180 000 units he has to scrap, such that an additional profit loss of 720 000 USD can directly be attributed to lost sales opportunities.

Example 3	
Total production volume:	1 000 000 tablets
Defect rate:	18%
Unsellable quantity because of poor quality:	180 000 tablets
Variable production costs per tablet:	5.00 USD
Regular fixed costs per 1 000 000 tablets:	1 500 000 USD
Regular profit margin per tablet:	4.00 USD
Profit margin reduction because of decreased productivity: 6.10 USD – 5.00 USD =	1.10 USD
Profit margin reduction because of decreased capacity: 1.83 USD – 1.50 USD =	0.33 USD
Decreased profit margin per tablet: 4.00 USD – 1.10 USD – 0.33 USD =	2.57 USD
Loss because of decreased profit margin: (4.00 − 2.57) USD/tablet × 1 000 000 tablets =	1 430 000 USD
Loss because of lost sales opportunities: 4.00 USD/tablet × 180 000 tablets =	720 000 USD

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If that was not enough, other opportunity costs, for instance a waste of management time, are caused by a severe quality problem. This is a cost category not to be neglected, since management compensation is usually very expensive for a company. Quality problems might either distract management from its normal, strategic tasks, or require the employment of special personnel. Either way, costs are incurred that can be saved when the quality level remains high.

For completeness we also have to consider the opportunity costs of *improving* the quality level, since the conscious move from a poor to a high quality level also generates costs that could be saved by *not* improving. These costs are mainly due to the manpower involved in the improvement effort and the technological or managerial remedy for the problem. One might think that these costs are also significant, such that a company has to carefully balance cost prevention and cost creation of a quality improvement project.

Yet, although the total investment for quality improvement might be significant, we should not forget two things. First, a quality improvement is an investment not a cost, because it benefits the company for several years. Therefore, only the depreciation rate of the investment is cost-effective per year. This reduces the cost burden significantly – in standard accounting the costs are only $\frac{1}{10}$ of the total investment amount since an investment is depreciated over 10 years. Second, the poor quality producer has to incur massive costs for inspection activities in order to guarantee that only acceptable products reach the market. These costs might even be higher than the costs caused by the quality improvement.

Let us for simplicity assume that the costs of improving and the inspection-related costs are of equal magnitude, such that they cancel each other out. We can then conclude that a poor quality manufacturer has to cope with production-, sales-, and management-related opportunity costs of considerable magnitude *additional* to the regular production costs. This puts the company at a serious disadvantage to any high-quality competitor. From the market side, opportunity costs are induced when defective products slip through inspection and end up in the hands of the customer – a point we have not touched at in our production-centric discussion. The customer might then re-evaluate the quality expectation toward the company. Product recalls can have devastating effects on the company's reputation and thereby on its bottom line and its share prices. In general, reputation losses can result in sales declines or price reductions [5], causing revenue losses and thereby additional profit losses.

Conclusion

The point we put forward is an inward view on efficiency – to be fair, most outside regulators in the pharmaceutical industry do not care much about this measure. Their only concern is that companies comply with quality standards since faulty products may pose hazards to human lives. Yet there is a clear link between well-managed, efficient production processes and the external quality: only by keeping the quality on a high level can we effectively guarantee that our products indeed comply with these regulations. Poor internal quality is always connected to poor external quality, no matter how much inspection is put in place [6]. Therefore, quality improvement is the most promising way to satisfy regulators.

However important, complying with regulations is only one side of the coin of economic success. The other is internal profitability. From the perspective of opportunity costs, poor quality does not seem to be an attractive option: the unit production costs are higher because of wasted inputs that have to be paid for and because of a reduced number of sellable products to bear the fixed costs. We have captured these two results in what we called the 'productivity effect' and the 'capacity effect'. Additionally, profit opportunities are foregone because the planned-for sales volume cannot be reached and sales might further decline when

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customers are disappointed by the purchase of faulty products that slipped through inspection.

Luckily enough, there is a way out of this dilemma: companies can improve their quality. The sooner they start with it, the better. After all, doing things right is cheaper and more fun than having to deal with opportunity costs. And by not foregoing profitable opportunities, a company can effectively add to its own competitiveness.

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