Trade-offs and their economics

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Cost-benefit analysis is a relatively straight-forward exercise for large discrete choices in natural resource supply chains such as transportation modes and site locations. When average or typical operations are well understood, the benefits of one choice over another can often be very one-sided, making the best choice obvious. However, we have found through the dynamic modelling of complex supply-chain logistics that many of the most impactful decisions relate to variability and are more continuous in nature. We call these decisions 'trade-offs' and evaluating them economically can help you optimise your investment once you have exhausted your present assets' capabilities.

What is a trade-off?

A trade-off is a decision of 'how much?' or 'how many?', rather than 'which one?' or 'go/no go?' Here are just a few examples of trade-offs and the real economic risk they present if they are either too conservative or too aggressive:

- Storage capacity: Insufficient storage capacity shuts in pipelines upstream and downstream, delays trains and ships, or forces plants to be shut down, resulting in millions of dollars in lost capacity or missed opportunity. However, additional tanks, stockyard lines, and storage buildings can cost upwards of $20 million each. How much storage capacity do you build?
- Fleet size: Insufficient fleets underperform during surges in demand, resulting in missed deadlines, lost customers and unsustainable revenue. However, excessive fleet capacity is unnecessarily expensive: unit trains can cost $15 million each and chartering a ship can cost $50,000 per day. How many locomotives, railcars, and ships do you buy or lease?
- Equipment redundancy: If you drive high utilisation on all of your processing assets, you will lose capacity and revenue every time there is a delay. Although installing spare equipment can mitigate these impacts, it can be wasteful and expensive in the extreme. What baseline utilisation do you plan for? How many hot and cold spares can you justify?
- Optimal inventory levels: Given fixed storage capacity, you have a choice of the average inventory level you keep. High inventory levels avoid shutting in downstream systems but frequently shut in upstream systems, and vice versa. Inventory carrying costs and the associated reduction in your working capital also need to be considered. How much inventory should you keep on average?

Each of these decisions helps reduce the impact of expected variability from seasonal volume surges and unit loads (trains, batches and ships). Of course, we assume you have already tried to minimise unexpected variability due to breakdowns and unplanned delays. While seasonal and unit-load variability remain necessary in many supply chains, they can cause you less grief if you estimate how much to expect and invest accordingly.

How do the economics work?

Trade-offs generally exhibit increasing net profits up to modest levels of investment in equipment and diminishing returns thereafter. Consequently, there is typically an investment level beyond which marginal profit is negative (ie, the capital costs of one more unit exceed the net present value of the revenue that the unit generates).

Figure 1 presents a sample economic trade-off graph that considers 10 motors in parallel production lines with spares to offset the variable breakdowns.

The x-axis shows the number of spare motors. Throughput increases as spare motors are installed to cover the occasional breakdown. However, the system's throughput begins to plateau once four spares are on hand; that is, there is 'sufficient coverage' for the variability. As a result, the cost of the fifth spare (and each subsequent one) outweighs the net present value profit of its lifetime throughput. You can observe this effect in two ways. Firstly, note that the total NPV profit is maximised with four spares and it decreases thereafter. Secondly, note that the marginal NPV profit per motor is negative beyond four spares.

One other observation about throughput is also worth noting. The fifth and subsequent spares still increase throughput, it is simply that their contributions are not enough to justify the investment. We recommend that you operate at your system's 'practical capacity', the throughput that maximises profit. Just because you can increase throughput, does not mean that you should.

Using trade-offs to make economic decisions

First, make sure that your existing system is as profitable as you can make it. Note that maximising profitability is not the same as minimising costs. Most supply chains have significant low-cost improvement opportunities. We have found that analysis of detailed historical operating data is a good first step to identify them. In a system with low-cost improvement opportunities, a trade-off mindset may not be your best first option; it may be possible to both improve performance and scale back on spending simultaneously. Tools to achieve these ends include Lean Six Sigma, Total Quality Management (TQM), and Theory of Constraints (TOC).

Capesize vessel moored at LNG berth, Peru

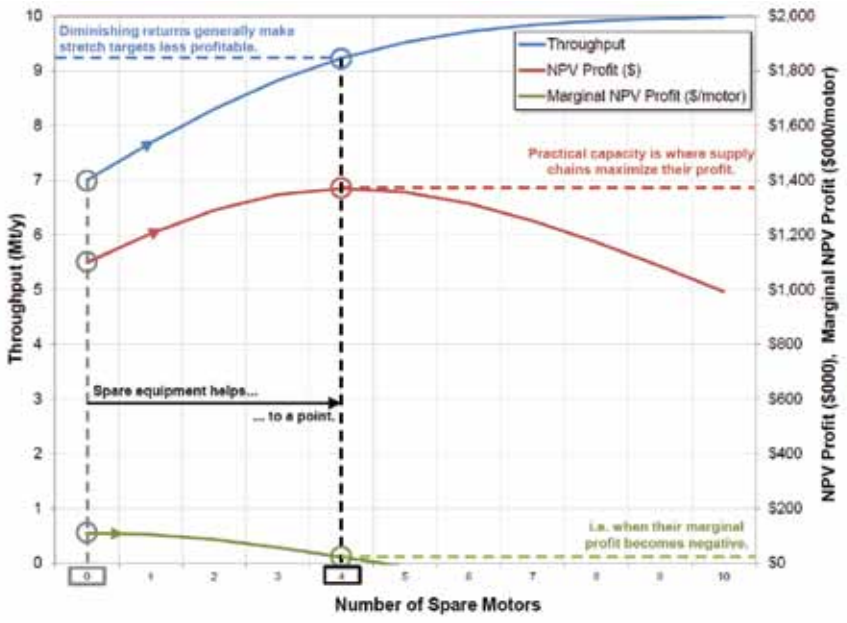

Figure 1 – Economic Trade-off (ten-motor example)

However, once you are convinced that capital investment is necessary to reach your company's economic goals, evaluating continuous trade-offs will help you right-size your investment. When selecting an economic analysis tool, we recommend Dynamic Simulation Modelling because it is reliable, data-driven and risk-based.

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About the author

Allen Funston is a professional consulting engineer at Ausenco who has optimised and planned multi-billion dollar organisations' natural-resource supply chains across six continents. Passionate about generating and sustaining measurable value through data-driven techniques such as dynamic simulation modelling, Funston has also pursued an MBA to integrate rigour into the development of his clients' global corporate strategies.

About the organisation

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Operating from 31 offices in 19 countries, Ausenco is a global and diversified engineering and project management company in the marine, bulk handling, mining infrastructure, energy, oil and gas, and in the power and industrial sectors. Ausenco provides unbiased, independent engineering and management services for projects of all sizes. From mines to pipelines, ports and bulk terminals to infrastructure, we deliver ingenious solutions to optimise our clients' resources.

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