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Taking Account of Uncertainty in Operations Management Decisions

by Danny A. Samson, University of Melbourne

In this column I want to offer my views on opportunities that come from the explicit accounting for and management of uncertainty in the key decisions made by operations managers. I will argue that it (it being the explicit accounting for uncertainty) generally should be done, generally is not done or is often poorly done, and that it can and should be done much better. I offer some views as to how improvements can be achieved.

First I offer my running definition of our field of operations management: I consider it to be the design, conduct, and improvement of the production processes of organizations, and those processes that support and interface them. Let us consider the nature and extent of uncertainty in these three key aspects of process design, conduct, and improvement. To begin with, uncertainty in this regard is simply meant as our inability to know the future consequences of the actions and decisions that we take in the present tense. We should acknowledge that the future is fraught with significant uncertainty which stems from many and various sources: technological, political, consumer and market forces, climate, competitor actions, etc. These lead to major challenges in predicting outcomes associated with decisions, such as capacity planning, process choice and design, facility location and layout, technological choices, supply chain design, supplier choice, purchasing policies, inventory policies, and production scheduling, to name but a few. Indeed, all significant decisions, and especially strategic decisions in operations management, involve outcomes that extend well into the future, which is unknowable to us. Yet we mostly behave as if this uncertainty is small in extent or not important. We often design and build things, such as factories, service centres

etc., assuming that they will work reliably and to specification (with assumed probability 1.0) in both a technical and business/market sense, whereas history tells us that this is rarely the case. Failure or severe underperformance of production systems, implemented technologies, products, and services in markets is presumably never intended by rational operations managers, yet is frequent in reality and often simply accepted as a “surprise outcome,” when in fact it is usually due to the under-management or underestimation of the uncertainty in prospect. This underperformance or unreliability applies equally to single pieces of equipment, oil and gas exploration, mines, processing technology, advanced manufacturing technology, new products and services, software systems (especially if administered by a university), and certainly also includes the failure of the last three laptops I have acquired from such well respected suppliers as Sony and Dell. Operations (and other) managers are often optimistic and make investments assuming the best possible outcomes but then suffer disappointment. Why not be realistic in prospect and fully acknowledge the performance uncertainty from Day 1, which might well lead to better resource allocation decisions in the first place?

Considering the key decisions of an operations strategy, such as capacity plans, facility layout and location, process choice and job design, push versus pull and lean, quality policies, technology choices, inventory policies and scheduling methods, what degree of certainty exists in the outcomes and the returns on investment for the organizations making these decisions? I will argue below that the uncertainty is not negligible, yet most formal and even informal decision justifications are made



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with little or no serious attention paid to that uncertainty. We assume it away, and pay for that assumption later.

Capacity decisions are fraught with uncertainty yet rarely is this uncertainty well accounted for. In sizing a chemical plant, oil refinery, assembly line, or even a cooking machine in a food products factory, the common rule of thumb being used is the "I reckon" method, and boards of companies, large and small, approve capital expenditure proposals on the assumption that: "If we build it, they will come, and it will work, and it will deliver a return on investment of x%: presented as a precise number!" The reality of capacity decisions is that there are both risks and return drivers of erring on the low side and on the high side, yet explicit assessment of such risk and return drivers is rarely conducted. In some industries, such as oil and gas, and parts of the financial sector, there are notable exceptions where powerful 'risk analysis' is indeed undertaken, yet we note that sadly this does not appear to be widespread. In short, capacity decisions are being taken and implemented, and plants are being built that are often way too big or too small without a full and proper weighing up of the risks of such outcomes.

Facility layout and location are decisions that also involve natural uncertainty. Which layout will work best? Which location will deliver the lowest cost, best supply reliability, and best delivery outcomes? It is often impossible to know for sure, hence the need to systematically identify, quantify, assess risk magnitude, and weigh up the various uncertainties associated with the options. This is easy to say, yet is infrequently done in a rigorous manner. More often we see facilities which have already been designed and implemented but are working less than acceptably, and therefore major costs are incurred when significant changes are made. When it comes to the location of facilities, even more is at stake than in layout decisions. Putting a factory or service center in what turns out to be the wrong region, country, city, or street location can be very expensive to redo. Yet still we see such decisions proposed and approved with scant attention paid to

the elements of uncertainty that pervade them. Again, with the fine exceptions of those who do engage in systematic analysis practices of "decision-making under uncertainty," we see operations managers frequently living with the consequences of poor facility design or locations that they regret for many years as a result of underestimating the uncertainties in such resource allocation decisions. Poor accounting for technical uncertainty, political uncertainty, and many other risk sources leads to unanticipated outcomes which in many cases could have been at least acknowledged as possible, ex-ante. Such accounting for uncertainty might have led to different decisions or at least better preparedness for the outcomes being not what was "expected" in the world that was otherwise assumed to be close to perfectly certain.

Operations managers are often concerned with innovation of products, services processes, technologies, and even business structures and models. New product and technology success rates are often quoted as being low, yet boards of directors are regularly asked to approve investment proposals which assume a world of perfect certainty. I have myself sat on a board that did so regularly, and looking back I can say that over time the optimism within the proposals became apparent and systematic, the uncertainty was severely undermanaged, and the accountability for projects "not delivering" was infrequently in place. New products/services and IT projects are particularly notorious for not delivering to the specifications and expectations as proposed and approved. Yet businesses keep doing this, though not fully and properly and sometimes not even scantily assessing and accounting for uncertainty. By far the majority of IT projects come in late, over budget, and may fail to fully deliver on their promises, just as most new products fail, yet managers blindly keep on investing and being disappointed in various types of innovations as if they were all "sure things," which they clearly (with the wisdom of hindsight) are not!

These same phenomena of people not explicitly considering uncertainty

and therefore under-managing it are apparent in the process of conducting operations and improving them, not just in the design and investment decisions of operations strategy. Daily, weekly, and monthly scheduling decisions often are taken assuming that equipment is 100 percent reliable, which it may not be. Staffing decisions are often made on the assumption that all people will always behave predictably and "to specification," which they do not. In the implementation of improvement initiatives such as quality circles, TQM, Lean, and Six Sigma, lasting implementation success rates are notoriously low, yet major investments are made in these with the assumption of 100 percent chance of success, which is generally not so.

Operations managers do not have a mortgage on poor practices in understanding, assessing, and allocating resources under uncertainty. Marketers and salespeople are notoriously optimistic and "blind" to downside uncertainties, and many financial analysts either were blind to them or chose to ignore risky consequences as part of the event stream leading to the recent global financial crisis. This recent crisis involved many decision makers across even the largest of finance houses completely misestimating or, even worse, ignoring the real risks that their organizations were taking on. Regulators did no better. These senior managers were generally graduates of our finest business schools, trained collectively by us! Either we failed them in their education, or they failed us in their application, or most likely, some of both occurred. Consider that if this is the quality of accounting for uncertainty and its impact in big decisions at the "big end of town," what is happening in SMEs? One can only hope that small business is doing it better than big business!

Fortunately, there are exceptions! Oil and gas exploration operations, which centre on managing uncertainty, are usually analyzed carefully in respect of risk and return. Uncertainty is explicitly assessed, using techniques such as decision trees and Monte Carlo simulation, for which excellent software packages exist. I have seen, over a decade ago, a

large bank which prudently constructed Monte Carlo risk analyses on its potential acquisitions, balance sheet, and profit/loss statement, taking full and explicit account of uncertainties. It clearly can be done, and is done by a minority of companies and executives.

The Fully Mature System of Accounting for Uncertainty

Start with the balance sheet and profit/loss statement. These would be forecast going forward for three, five, and perhaps ten years, using probabilistic risk analysis. Then, any strategic initiative, such as a takeover, a major new factory, new product, or capacity expansion, would also be considered in terms of their probabilities of future outcomes and their impact on the profit/loss position and balance sheet. Currently such investments and operations strategies are valued by measures such as payback period or NPV. Using explicit risk analysis, major initiatives would be valued first through a rigorous analysis of their probabilities of outcomes and then aggregated with the firm's other prospects, perhaps using probabilistic NPV, to consider their impact on the key financial outcomes of the firm (on the P&L and balance sheet). This is eminently doable yet relatively rarely done compared to those who either implicitly think a little about "riskiness," or those who hardly consider uncertainty at all and stumble into the future and the many "surprises" (usually downside surprises) that it brings.

If Decision Tree and Risk Analysis Are so Useful, Why Are We Here?

The primary and most useful ways to take full and explicit account of uncertainty is to use either decision trees or Monte Carlo risk analysis. These methods are relatively challenging to learn, teach, and practice when the alternative is to take the easy path of essentially ignoring uncertainty, or just acting more conservatively (and perhaps doing a sensitivity analysis) when one senses uncertainty. These methods are based on the explicit use of probabilities as the language and measurement scale of uncertainty. Many students report that probability (especially Bayes Theorem) is one of the more challenging concepts to

learn in their MBA. Perhaps it is because we don't generally teach it very well!

As to professional practice, it takes time and some significant effort to construct a risk analysis or even a decision tree rather than to ignore uncertainty and do a simple, fast break even analysis, NPV or similar. And the market for implementing decision making under uncertainty is just not efficient! Imagine a board of directors that might be presented with a simple proposal to invest in an expansion of capacity. The idea would need about 30 minutes of discussion at a board meeting, and it would propose simply (actually, simplistically!) that the return on investment would be a knowable X percent. This is simple, clear, and can be signed off. The alternative that I am proposing is a tougher mental task, requiring significantly more effort from the proposer and the board, and an explicit acknowledgement that we simply don't know everything we would like to know about the investment! Such a proposal would involve a discussion of the drivers of uncertainty, the categories and magnitude of it, and the explicit ("in your face") approach to uncertainty. Many would feel such an approach to be less likely to achieve approval and sign off, simply because proposals would look and feel more risky, complex, and less certain than if the risk factors are ignored. So indeed, they very often are ignored! Further, there is little or no accountability later when the proposed outcomes that justified the investment do not accrue. So the cycle of poor practice continues unabated. Risk is somewhat better managed in the related field of project management, but there is still a lot of risk that is "assumed away" there, at least until the problem hits the fan.

What Can We Do about This?

As academics, we can substantially influence the development and practice of operations management and related strategic decision making. I propose the following collective actions.

One, we should further research the methods and effectiveness of explicitly taking uncertainty into account in all aspects of key operations management decisions. The fields of decision modeling/operations research have become

quite disconnected from mainstream operations management in the past 25 years, with the current generation of up-and-coming operations management academics doing mostly empirical and other field studies that purport to explain aspects of performance with some set of practices. In short, we study "what is happening" well, but we study "what should be happening" poorly. The evidence for this claim is found by considering the content of leading journals such as the *Journal of Operations Management* and *Decision Sciences*. It seems we have almost forgotten the normative or prescriptive approach, in which we model or simulate key decisions to learn about them, and gain insights about them from such modeling, such as to inform decisions. The gap between the daily concerns and real needs of operations managers and the models created by operations researchers needs closing. When useful models and templates for decision making under uncertainty for decisions such as new technology, capacity planning under uncertainty etc., prove their worth, there will be the possibility of widespread take up.

Second, operations management curriculum, textbooks, and leading journals rarely model nor prescribe an improved accounting for uncertainty these days. In our research, the "publish or perish" imperative has us so absorbed with the rigorous methodology associated with observing what is going on in the field of professional practice that we have lately pretty much ignored our duty to get out in front of the curve of leading practice and devising or advising on significant improvements. This was and is the duty of the field of operations research, but it has had too little of an impact in recent decades and, unfortunately, has become quite detached from the world of professional operations practice. This can be fixed if we want to do so.

Third, we should connect up the teaching of decision making under uncertainty techniques to the problem classes of operations management. Many of us currently teach topics such as capacity planning, facility location, inventory

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This is the last issue to be published during Ram Narasimhan's DSI presidency. In his last letter as president, he reviews an exciting year of milestones. One exciting development of his tenure is the creation of a new region in Europe. The first meeting of the European Region is to be held during July 2-3, 2010, in Barcelona, Spain. Ram offers a number of suggestions for continuing progress of our Institute. Our new president, Keong Leong of the University of Nevada - Las Vegas, has declared his year in office to be the year of implementation.

In the current issue of *Decision Line*, we bring you a new set of thought-provoking essays. In the POM column, Feature Editor Danny Samson of the University of Melbourne discusses taking better account of uncertainty in decisions. He argues that in operations management decision making, uncertainty is generally not taken into account to the extent that it should be.

The Classroom feature column presents an essay on "Learning Business Process Integration," authored by Thomas Rienzo and Bernard Han, both of Western Michigan University. The authors note that while various ERP-related research issues and teaching pedagogies have been studied, "little research is available with findings related to the acquisition of business process knowledge through utilization of ERP software."

In the Deans' Perspective feature column, Marc Orlitzky of Pennsylvania State University, Altoona, and Diane L. Swanson of Kansas State University ask, "Do executives who prefer exorbitant salaries downplay ethics?" They surveyed a couple hundred executives to determine "if there was any relationship between executives' preference for salaries structure and their attitude toward ethics." They found "a positive correlation between the executives' preference for a highly stratified distribution of organizational income and an aversion or reluctance to account for ethical values in their decision making."

In this issue we offer the first part of a two-part essay by co-authors Varun Grover and Jason Bennett Thatcher of

Clemson University in the Doctoral Student Affairs feature column. The authors offer students' perspective on the first five of a total of ten mistakes students make in their doctoral programs. The remaining five will be discussed in the next issue of *Decision Line*.

In the Bookshelf column, Glen McEvoy of Utah State University reviews Jonah Lehrer's book, *How We Decide*, published by Mariner Books. My favorite Lehrer quote is, "The secret to happiness is not wasting time on irrelevant decisions," advice he received from a wise decision scientist.

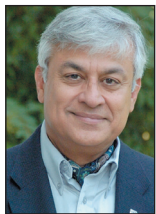
Please continue sending us your essay contributions. Happy reading! ■

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policy, innovation and new product or process development, lean, total quality, and innovation, without much or indeed any explicit accounting for uncertainty. If and when we teach it well, then and only then can we hope and expect it to be competently and professionally practiced.

Fourth, once we integrate concepts of measuring and accounting for uncertainty into operations management, then the status of the field of operations management will rise in prominence as a real contributor to strategy and whole-of-company outcomes. Operations decisions will be seen for what they are: as major determinants of the competitive outcomes and performance of firms. Perhaps operations management as a field can mature in this way and rightfully and most valuably take its place at the strategic top table.

This call for improved operations management decision making through the explicit application of known techniques, such as decision trees and risk analysis, is aimed at influencing all of us, from textbook authors, to educators, researchers, and practitioners. We can and should strive to do better by making use of such sound techniques, even if it is a little harder than assuming key uncertainties away! ■



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