Models and Modelling: A Case Study



(Magritte, 1929)

# “Dell’s Channel Transformation: Leveraging Operations Research to Unleash Potential Across the Value Chain”

## Introduction

This essay reflect on aspects of models, as used in Management Science, and on the modelling process itself, with particular reference to the industrial case study (Martin et al., 2014) that appears in the title above. The article chosen was published in the Operations Research journal *Interfaces* in January 2014 and was a finalist in the 2103 Franz Edelman Awards competition, an annual contest designed to highlight exceptional examples of OR/MS practice.

At the time of publication, Dell Inc. was the world’s third largest personal computer vendor in terms of market share (iCharts, 2014). In their paper, the authors describe three main “solutions” [models] that were developed in response to Dell’s transition from a predominantly configure-to-order (CTO) sales approach to a supply model that emphasised delivering fixed hardware configurations (FHCs), as part of a response to evolving customer attitudes to purchasing technology, including personal computers. For the purpose of this essay, the focus will be on just one of these three models, namely that which the authors refer to as the “Online Conversion Rate Accelerator” (“OCRA”).

## Online Conversion Rate Accelerator

The Online Conversion Accelerator is a model of the various components that appear on a sales web page on Dell’s website, along with certain technical and business constraints, formulated as a non-linear, mixed-integer program. More specifically, the objective function is to maximise the “conversion rate” (that is, the proportion of customers browsing the web page who then progress to placing an order) which is modelled as the sum of the “main effects” and “interaction effects” relating to a specified set of permissible webpage components, such as “buttons” and “deal banners”, with each component represented by a binary variable and an associated coefficient. The model constraints include a specified minimum and maximum number of page components; merchandising restrictions on certain combinations of FHCs being displayed on the same web page; a restricted permissible set of combinations of page components; upper and lower bounds for product prices; limitations on permutations of website navigation elements; and an upper limit on the time taken for a web page to load.

The stated purpose of the OCRA model, as defined by the model’s objective function, was to maximise the online customer conversion rate. The authors report that “various merchandising changes made as part of OCRA helped increase the online FHC sales mix from seven percent in 2010 to 38 percent in 2012”. There are a number of issues with this statement. To begin with, the proportion of sales that are FHCs is clearly not the same as the stated objective, that is the proportion of visitors to the sales page who subsequently go on to complete a purchase. Further, as with the two previous claims, in the absence of evidence for a causal relationship, the predicate of the statement is something of a *non sequitur*: one might reasonably speculate that an increase in FHCs as a percentage of all sales could be anticipated simply on the basis of Dell switching to a FHC sales model, optimised or not, in preference to a CTO sales model.

The Online Conversion Rate Accelerator model was developed with a view to informing senior executives within Dell, specifically Dell’s “online business managers” (OBMs). Interestingly, whilst regional variations of the model were generated (on the basis of location-specific constraints), the models were implemented centrally by a “global project management team”. There appears to have been an initial degree of reluctance to accept and adopt the model, apparently owing to the fact that some of the model’s conclusions were contrary to existing beliefs: the authors describe the example of an unanticipated, inverse association between the number of deal banners on a web page and the associated conversion rate. This preliminary resistance dissipated, seemingly on account of the results of successive, incremental “pilots” of the model, leading progressively to managerial acceptance, subsequent full-scale roll-out and finally to adoption in preference to the prior approach of page design based on expert knowledge and acumen.

# What constitutes a “good” (Management Science) model, and what are the characteristics of a good modelling process?

## What constitutes a good model?

A model should be simple, with detail added as required rather than removed (Salt, 2008), revealing a system’s most salient features (Little, 2004; Wahlström, 1994). Vaandrager (2014) suggests ‘Occam’s razor’: “among models with roughly equal predictive power, the simplest one is the most desirable” with the model’s purpose dictating ‘importance’ (Pidd, 1999), although ‘simplicity’ must balance ‘completeness’ (Little, 2004).

Dewey (1938) said, “A problem well put is half solved”. Appropriate problem structuring is crucial in optimising a model’s level of detail (Pidd, 1999) and incorporates Williams’ (2008) inducement to make use of “formal, theoretically based languages”. A problem expressed in terms of familiar algorithms or previous publications may permit ready familiarity with the model, a quality Morris (1967) calls “relatedness”.

A clearly stated object and purpose are desirable although one does not imply the other (Pidd, 1999) and several purpose-specific models are preferable to a single multi-purpose one (Vaandrager, 2014). Willemain (1994) also favours the creation of “a unique model for each problem” whilst Landry *et al* (1996) and Wahlström (1994) note that a model’s purpose incorporates elements of knowledge creation, thought promotion, increased understanding and decision support.

For a model to be useful, its output should be neither misleading nor obvious (Wahlström, 1994). The usefulness of a model is tied to the circumstances of its creation and so a change of ownership, scenario or environment may prejudice the model’s value (Phillips, 1984). For a model to be ‘usable’ the interface must be intuitive (Little, 2004), although there is a trade-off between usability and adequate intricacy (Landry, Banville and Oral, 1996) and usability may also be affected by financial and resource implications (Gass, 1987).

A good model is flexible by virtue of adaptability or extensibility. Adaptability connotes evolution of capability with retention of original objective, a feature advocated by Little (2004). Extensibility, conversely, implies a branching of purpose either by progressive growth of the original model, or by seeding a generation of related models designed for application to a class of similar (yet unique) problems (Vaandrager, 2014).

Robustness is a favourable quality, with a robust model being capable of tolerating reasonable deviations from the underlying assumptions (Morris, 1967), or as Little (2004) puts it: “Robust. Here I mean that a user should find it difficult to make the model give bad answers”. The output of a model should be a plausible portrayal of the system (Wahlström, 1994), although its validity is dependent on the subjective appraisal of the model’s output by those who engage with it (Landry, Banville and Oral, 1996).

Salt (2008) warns against concealing the underlying workings of a model, (“the black box mistake”) because, as Pidd (1999) concurs, hidden mechanisms may engender distrust, potentially rendering the model useless.

Attempting to rank some of the qualities above, Willemain asked “twelve selected expert modelers” to list the “qualities of an effective model” in order of importance (Willemain, 1994). The summary of responses was as follows: “1) validity, 2) usability, 3) value to the client, 4) feasibility, and 5) aptness for client’s problem”.

Finally, Vaandrager (2014) contemplates the desirable features of a model thus:

“Often, the criteria are hard to meet and typically several of them are conflicting. In practice, a good model is often one which constitutes the best possible compromise, given the current state-of-the-art of tools for modelling and analysis. But a truly beautiful model meets all the criteria!”

## What are the characteristics of a good modelling process?

Morris (1967) notes that learning about modelling must be learnt separately from learning about models, whilst Pidd (2009) makes the slightly bolder claim that the former is a higher endeavour than the latter, and although it may seem to some that modelling is ‘more of an art than a science’, the notion that this implies that good modelling cannot be taught is refuted by Wahlström (1994). The features that characterise a good modelling process, in general, relate to either the model, the client, or the analyst him/herself.

A good first step is to take Pidd’s (2009) advice to “divide and conquer” the problem into smaller, simpler sub-problems, a strategy advocated also by Powell (1995) who suggests that a sensible structure for the overall problem tends to evolve naturally as a by-product of such an approach. A logical next step is to settle upon a suitable formulation of the (sub)problem(s) under consideration (Gass, 1990) and here it may be possible to gain a time advantage by selecting, where appropriate, a recognised formal model structure (e.g. linear programming, queuing theory) (Morris, 1967) rather than a bespoke solution, although it is crucial to establish the feasibility of whatever solution approach is selected (Gass, 1990). Powell (1995) is a proponent of starting with what he calls a “prototype”, essentially a ‘rough and ready’ model that provides ‘a’ (perhaps inadequate) solution to the problem, before proceeding with what is perceived by many authors as one of the central tenets (or, for Wahlström (1994), a *sine qua non*) of a good modelling process: refinement.

The process of honing an initial, rough model should not be linear, but rather should involve iterating through a loop between making some change to the model and testing the effect of the change before making further changes (Morris, 1967); it may be necessary, at some stage, to take a few steps backward in the development process in order to experiment with proceeding in an alternative direction. An example of this ‘change and check’ cycle might be the exploration of the effect of altering model parameters to judge the size of effect and hence the relative importance of the parameters (Phillips, 1982; Phillips, 1984). In a similar vein, the difference in output between successive models will be instructive in judging the effective return of each refinement (Powell, 1995) and so act as a rough guide to arriving at an endpoint that balances model simplicity with accuracy. There is universal agreement in the literature that one of the hallmarks of good modelling is involvement of the client or ‘problem-owner’ at different stages of the development process (Morris, 1967; Landry, 1996; Phillips, 1984) and was one of the key traits exhibited by Willemain’s (1994) group of “expert modelers”.

Prior to deployment, there should be a testing phase to confirm that the model’s output is realistic (Gass, 1990) - but not predictable (Wahlström, 2004) – and that the model itself is actually usable by the client, as the validity and accuracy of output are necessary but not sufficient conditions for the model to be usable (Willemain, 2004).

The interpretation phase of the modelling process presents an opportunity to the diligent practitioner to recall the earlier caution regarding the distinction between the model and reality and to resist any temptation to regard the model’s output as ‘the result’ (Salt, 2008) in keeping with Barabba’s Law[[1]](#footnote-1). Instead, it should be acknowledged that it is only by admixing the model’s output with human cognition that appropriate decisions can be made (Pidd, 1999; Salt, 2008).

A ‘good modelling’ process will also be well documented (Gass, 1987; Gass, 1990) and have a formal maintenance plan (Gass, 1990). Willemain (2004) also draws attention to the desirability of good communication, teamwork, self-organization and resourcefulness.

# Evaluation of the ‘Dell’ model and modelling process

The Online Conversion Rate Accelerator model displays many of the sought-after qualities discussed above. At the outset, the problem appears to have been formulated as a linear programming model, broken down into three main constituent sub-models, with the output of one acting as the input to the next in succession. One imagines that this may have been a backwards, rather than forwards, development process along the following lines: 1) choose linear programming structure, 2) determine model constraints, 3) decide combinations of web page components to act as decision variables by creating sub-model based on multivariate analysis and A/B testing, 4) decide which are the critical web page components from which to construct combinations in the first place by creating a further sub-model which in turn consists of multiple simple models running in parallel based on different data-appropriate techniques. Thus, we have evidence of the endorsed approach of breaking a problem down into smaller parts as well as relative simplicity of these components.

The object of the model (“maximise conversion rate”) is clearly stated, but there is perhaps some confusion over its purpose. In discussing the effects of the model, the authors refer to increasing the number of FHC sales as a proportion of total sales; an improvement in online customer satisfaction; and the “incremental margin of a page”, which does at least appear to be linked to ‘conversion rate’. Given that none of these objectives were described in advance of the model description, one wonders to what extent an association between these factors and the model are indicative of a *post hoc**ergo propter hoc* fallacy.

There is no indication of the development of a ‘rough and ready’ primordial model at any stage, although the authors do allude, on p61, to an iterative refinement process at a later stage, with website designs being deployed and tested, instigating fresh designs of webpage components and changes to website encoding, followed by re-testing in a cyclical fashion. This refining process was pursued in conjunction with the client (specifically, the “global project management team”) and there are further instances of client contact during the modelling process. For instance, in order to identify region-specific constraints, such as webpage button colours, the analysts worked closely with the client’s “sales, marketing, branding, merchandising, development, and data infrastructure teams”. Also, online business managers (OBMs) were involved at several stages of the modelling exercise; they reviewed the inputs to the linear programming model and ratified webpage designs prior to deployment.

Despite the tenuous nature of some of the purported benefits accruing from the model, there is a sense that, on the whole, the model was ‘useful’, and a specific example of a surprising finding arising from the model is given on p62: the ‘conversion rate’ was found to be inversely proportional to the number of deal banners on a web page, a relationship quite contrary to that which had previously been held to be true.

The fact that a series of website designs were “piloted” attests to the interaction between model output and human interaction and judgement, as opposed to simply allowing the model alone to dictate the website content and layout. Also, the creation of regional variations of website design alludes to model flexibility, avoiding the necessity to build a fresh model for each region from the ground, up.

Some of the desirable characteristics discussed in the previous section are left open to speculation in this case. There is no discussion within the article of the costs (both financial and resource) engendered; there are no details provided of the user interface, or the transparency of the inner workings of the model; and no mention of the model’s ability to continue to produce valid output in the face of changing parameters: might evolving market conditions, or improvements in server capacity for instance, lead to a change in one or more of the model constraints and what would be the effect?

Finally, of the modelling process, we can deduce nothing with respect to either model documentation or plans for future maintenance, adaptation and extension, or scaling.

# A successful modelling exercise?

Much of the available opinion within the literature as to what constitutes a successful modelling exercise has been distilled by Williams (2008, pp.256-276) and so a practicable approach to assessing the success of the case study under review here is to juxtapose it with Williams’ summation of the relevant performance indicators.

We have already remarked upon the influence of the client’s perceptions, that is their pre-existing beliefs and values, on the modelling process, but Williams takes this to a meta-level: it is not so much the client’s perceptions, but the analyst’s perceptions of the client’s perceptions that exert an influence. Thus, a key characteristic of a successful modelling exercise is the ability to comprehend the social and political hierarchy that exists within the client organisation and the attendant implications at an individual, group and organisational level. Accuracy, validity, usability of a model notwithstanding, it is unlikely to be utilised if it has the potential to upset the balance of power between key stakeholders of the problem, or conflicts with an organisation’s ethos or ‘culture’.

Williams also stresses the importance of realising and acknowledging that managers tend to make decisions in a manner that contrasts with that of a typical analyst. Mathes (1969) made a similar observation, which cannot be bettered by paraphrasing:

“The difference (managerial) people know only two degrees of probability, zero and one, and the similarity (scientific) people recognize every degree of probability except zero and one. The difference people tend to act before they think, if they ever think; whereas the similarity people think before they act, if they ever act.”

Perhaps more taxing is Williams’ contention that some managers may even be predisposed to greet any form of scientific analysis with a mix of antipathy and suspicion, perhaps fearing a challenge to a more intuitive decision-making process. Rightly or wrongly, if this creates any difficulty the consensus view is that the onus is on the practitioner to accommodate and work with the manager’s perspective, not *vice versa*. If the analyst has made a conscious effort to perceive the socio-political dynamics of the organisation, then there is scope to build a rapport with the client and, hopefully, transmogrify suspicion to trust. We see exactly such a scenario reported in the Dell case study, with the authors commenting that “convincing senior management to accept OR as a decision-making tool was a major challenge”. The analytics team approached this initial resistance by developing pilot programs, where the strategy suggested by a model was justified by real-world implementation on a small scale, thus gaining gradual credibility and acceptance in piecemeal fashion.

There are other measures of a successful modelling exercise that are perhaps more generic, in the sense that the same indicators are applicable in other professional and technical fields beyond management science. Some are simply societal norms that largely apply at the level of the individual, such as observing common courtesy, punctuality, using appropriate forms of address for a given relationship and context etc.; others are more reflective of the professionalism of the analyst as a business, such as whether or not the project was delivered within an agreed timescale and budget; whereas others still are more tangible, such as the receipt of requests for further analyses from the same client, referrals to other potential clients, or the accolades of one’s peers as in the example under consideration here.

In conclusion, the Online Conversion Rate Accelerator model, despite a few reservations pointed out above, largely fulfils the requirements discussed above for a “good model” and a “good modelling process”. There is an absence of discussion, within the paper, of many of the criteria with respect to the definition of a “good modelling exercise”. Nevertheless, the article concludes with a quotation from Dell’s CEO, Michael Dell, in which he states: “Using operations research, we can optimize profitable growth across various sales channels with a level of insight that was never before possible”, suggesting by its content and inclusion that both the client and the analysts deemed the exercise to be a successful one.

(3264 words)

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1. Barabba’s Law: “Never say the model says.” (Barabba, 1994) [↑](#footnote-ref-1)