Quick and Rigorous, Strategic and Participative: 12 ways to improve on the expected tradeoffs

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Abstract

Lyneis (1980, 1999) describes a phased approach to modeling that has proven successful for large strategy consulting engagements. This process usually requires months of modeling effort and multiple iterations to achieve the level of detail required for specific answers. Strategic analyses are episodic, however, and managers expect faster turnarounds and more specific, trusted results than is possible without a detailed, calibrated model already in place. We present here a refinement to the phased approach, which might be called lean strategy modeling, that is able to deliver substantial value in just six weeks. It increases the scope of testing and validation on what would otherwise qualify as an insight model. The process is divided in three stages: Issues definition and prioritization; model development and analysis; model-based analysis and strategy exploration. The approach is illustrated with an example about a client's degree of control over new technology diffusion in an emerging market.

Keywords: System dynamics**,** business strategy, corporate policy, phased approach, lean approach, scientific method, model building, consulting.

I. Introduction: Clients are impatient for results

PA Consulting Group's Decision Sciences Practice (which includes the former Pugh-Roberts Associates) has been fairly unique in developing large, fully calibrated models. These models are constructed over periods of months, with the purpose of providing the client specific numerical answers to high-stakes strategic issues. Lyneis (1980, 1999) calls this method of modeling "a phased approach", since it consists of four major phases: 1) business structure analysis, 2) development of a small, insight-based model, 3) development of a detailed, calibrated model, and 4) on-going strategy management.

These phases can be described as successive applications of the scientific method to Business Strategy. Graham (2002) describes System Dynamics as the applied science of strategy, because it allows framing of the issues in terms of hypotheses that can be tested using simulation. In that context, each phase can be seen as a cycle around the scientific method loop shown in Figure 1.

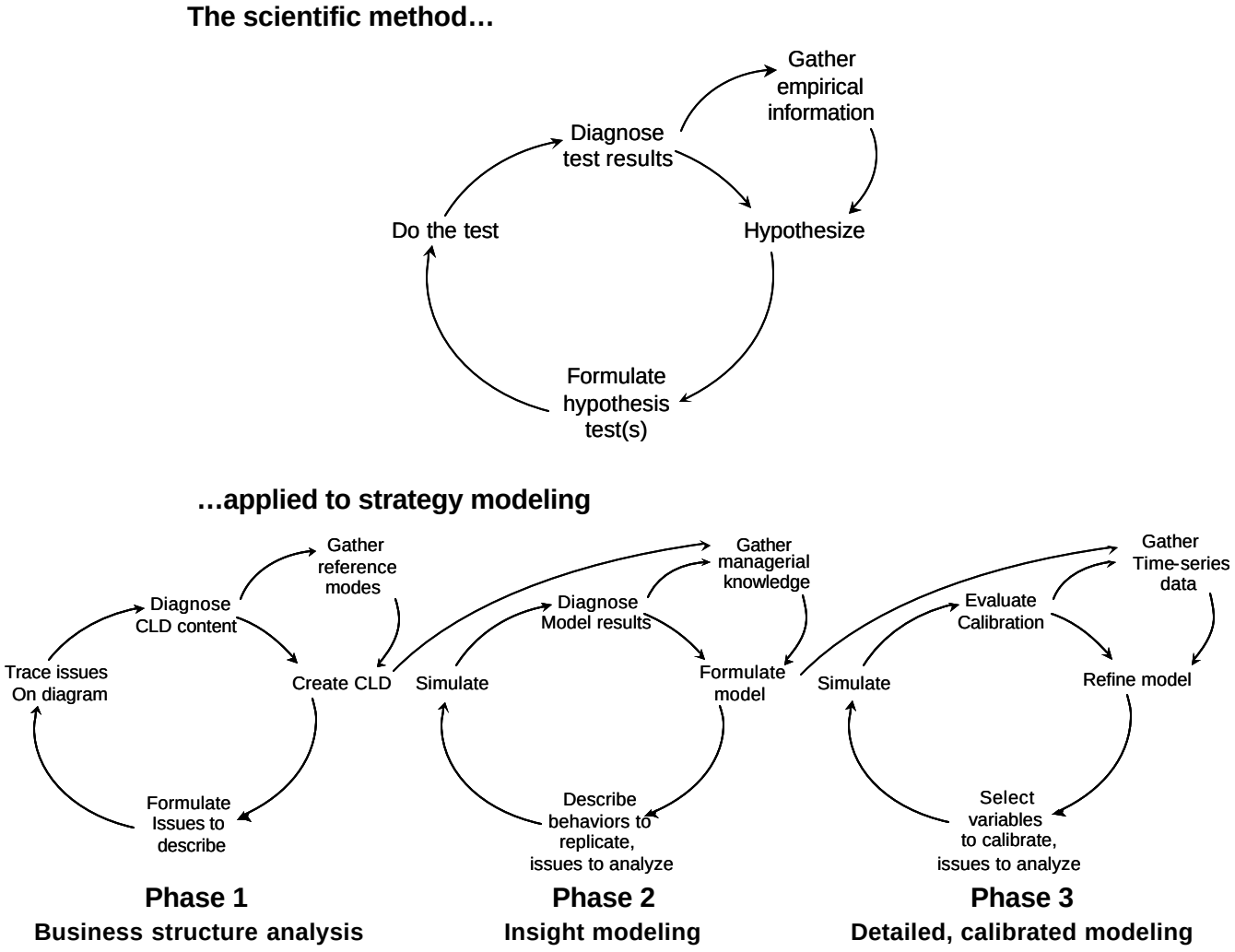

Figure 1. Applying the scientific method to strategy modeling

The first two phases, Business Structure Analysis and Insight Modeling, roughly coincide with the "orthodox paradigm" (labeled as such by Graham and Walker 1998), currently taught in business schools and broadly applied in the field. It relies on group model building (Vennix 1992, Andersen et al. 1997, Andersen and Richardson 1997, Richmond 1997) to collectively generate dynamic hypotheses and test them using immediately-available information from the client.

Business structure analysis, which relies on Systems Thinking techniques, delivers value in a matter of days. However, the amount of testing and validation possible at this stage is limited to apparent consistency between causal diagram and anecdotal evidence.

As we move to insight modeling, it is possible to observe behavior modes consistent with the mental model of managers, and explore the impact of alternative policies on performance.

Typical insight modeling does not emphasize either calibration to data or calculation of confidence bounds around the results. This is the result of a strong tradition that can be traced back to Forrester (1961), e.g., Section 13.7, which emphasizes that a model's validity relies on its ability to predict behavior characteristics, not specific numerical estimates. Graham (2002) discusses the origins of the historical bias against point-by-point quantitative validation.

The insight modeling process calls for significant testing, in the form of extreme conditions testing, policy sensitivity, and others (Forrester and Senge 1980). However, it is hard for insight models to establish a level of confidence in numerical results adequate for managers to be comfortable using model results in decision making. (See Homer 1997.) This is a nontrivial barrier to adoption in the corporate strategy realm: the inability of the model to replicate the quantitative, not just behavioral, performance of the system undermines the credibility of the process, sometimes to a major extent.

On the other hand, the first two phases of the process are relatively inexpensive. Detailed, calibrated models, which correspond to phase three of the approach, are more difficult to construct and validate, and therefore are only justified when the stakes are high enough. In that case, the client must either understand the intrinsic value of an in-house System Dynamics capability or be willing to wait a few months to obtain quantitative, actionable results.

More often than not, however, strategic decisions cannot wait months. Quarterly financial reporting drives companies to respond quickly and decisively to threats, or risk a negative market reaction on the next earnings season. Technological change and industry restructuring are forcing companies to accelerate their reaction time to market opportunities, or risk disappearing in the next wave of consolidation.

We strongly believe that a detailed, calibrated System Dynamics model can be a powerful tool to accelerate decision-making. Building that capability takes time, however, and it requires substantial trust from management that the outcome of a several-month-long effort will add significant value to the company. Building such trust can only be done through long-term relationships and a strong track record with members of the staff, perhaps from previous modeling engagements. These conditions are not always available, seemingly setting a limit to the potential of System Dynamics to become a mainstream method of developing corporate strategy.

We describe here a refinement of the phased approach. It relies on advancing the validation process of a small, insight-type model so that it can provide quantitative guidance in a shorter period of time, compressing the horizon of value delivery from months to weeks. This validation process relies on a sharp definition of the model's purpose and boundaries, "hard" data collection from the start, and extensive model testing with the help of automated techniques.

This "lean" approach challenges the linear relationship traditionally observed between the time dedicated to model development and the scope of testing (Figure 2).

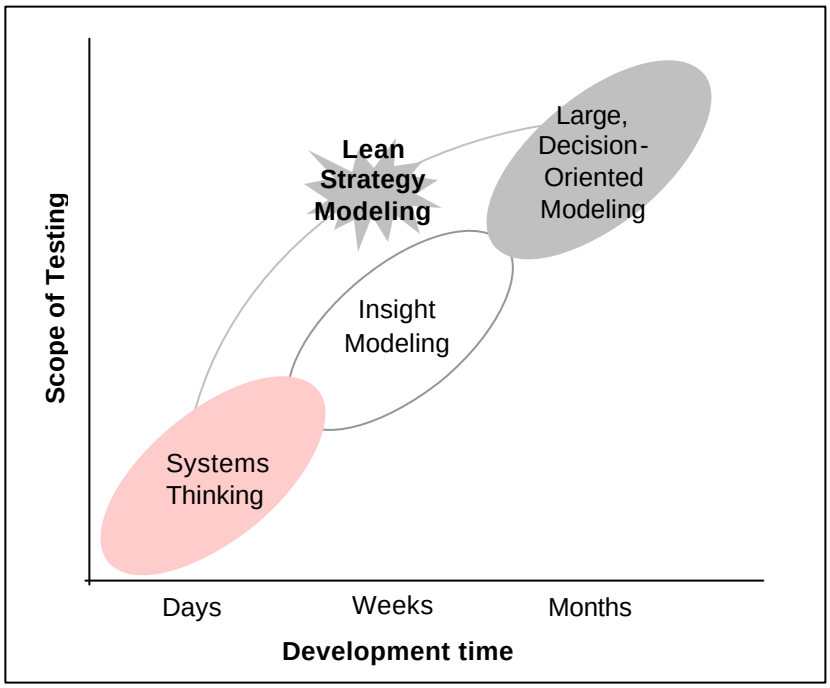

Figure 2. "Lean" strategy modeling falls above the trend line

A leaner approach overcomes the tradeoff between time and scope of testing, and in this way can become a much more effective way to introduce System Dynamics to corporate strategy functions.

Section II describes a six-week engagement that illustrates the feasibility of a leaner approach. Section III explains the factors that enabled the effective delivery of a lean strategy model. Section IV concludes with an exploration of its generality and implications for executing modeling engagements in the future.

II. Case example: Service delivery in an emerging market

The client, a service provider in an emerging market, wanted to understand the drivers of product adoption and the degree of control available to the company over the final penetration of the market. Previous internal efforts to answer this question had used market benchmarking techniques, as well as econometric, open-loop approaches that yielded limited insights.

Frustrated with lack of clear implications, the client engaged PA to improve its understanding of market dynamics and develop strategies to extract maximum value from the operation. We divided the engagement in three stages: Issues definition and prioritization; quantitative model development; and model-based analysis and strategy exploration. Each stage of the engagement lasted 2 weeks.

1) **Issues definition and prioritization**: The engagement started with a day-long session with our coach, a System Dynamics enthusiast and member of the client team. During that session we obtained a preliminary view of the company's top issues, as well as references to data sources. The importance of exploratory data analysis from the start of the project cannot be understated; instead of relying on mental recollections of important variables, we had access to monthly time-series data collected during the last 9 years of operation for balance sheet and income statement items, as well as service usage patterns and customer base demographics. Two factors were instrumental in accelerating data collection and analysis:

    a. The homogeneity of the company's services made possible the use of high-level executive reports as an appropriate level of aggregation to develop the initial dynamic hypothesis.
    b. While many issues remain with respect to data quality and choice of variables to be collected, the arrival and diffusion of data warehousing and ERP systems in large corporations provided access to several years of historical monthly time-series data for most key business variables. Having this kind of access without weeks of data collection effort was a luxury until very recently (particularly in foreign markets).

    Using the information from the first session, the PA team relied on previous modeling experience in the same industry to develop a qualitative dynamic hypothesis, represented through a causal loop diagram. The objective was to take full advantage of previous modeling experience to accelerate the process of learning. Many of the relationships had already been validated in previous engagements, so the discussion could move beyond basic industry dynamics, to focus on how decisions are made for key business levers, such as pricing or capital expenditures. Far from being seen as an "imposition" of a mental model, this provided credibility by going beyond plain facilitation and bringing content and experience to the discussion.

    The first stage of the engagement concluded with a 2-day conceptualization workshop, which had three objectives:

    a. Prioritize the issues to be solved during the following four weeks;
    b. Refine the initial dynamic hypothesis to confirm that the qualitative model captures all key issues;
    c. Get buy-in from the leadership team that their industry views and issues are being understood.

The first day started with a session describing the value that System Dynamics can bring to the organization (with 12 people attending from the client organization, our coach had not been able to provide more than a passing reference to the methodology). A discussion of key strategic issues followed, with the objective of prioritizing and guiding the modeling process to answer only the most urgent questions. For example, competitive pressure was seen as less critical than pricing and market saturation, and therefore it was decided that the quantitative model would focus on understanding market demand, with a much lighter treatment of market share dynamics. The day concluded with a review and refinement of the causal loop diagram, which focused, as expected, on refining decision rules around price setting, capital expenditures and operational budgets.

The second day focused on setting the boundaries of the quantitative model. It was clear to all participants that a 6-week effort would not yield a comprehensive model of the industry. However, it was also clear that the qualitative model provided the "blueprint" for the eventual construction of such a model, and that it would be built in phases. The model boundaries defined through this exercise focused on understanding the dynamics of market demand, but with a thorough treatment of financial implications in order to calculate the impact of strategic changes on shareholder value.

2) **Quantitative model development**: The second stage of the engagement focused on two areas:
    a. Refining data sources to eliminate information conflicts, and
    b. Developing and calibrating the model.

Internal data sources, together with appropriate external market studies, were made available to the modeling team. Exploratory data analysis quickly showed flaws in the sources, which had to be clarified through interviews. This led to a substantial revision of the reference modes, and in some cases forced the modeling team to conclude that a different level of aggregation was necessary for key cost items. Far from being a hindrance, disciplined data analysis was one of the main enablers of accelerated modeling during this stage of the engagement.

Once we had achieved a reasonable level of confidence in our data sources, it was possible to develop the preliminary model in a very short time (about 10 days for structure deployment and calibration). Judicious use of previous models, together with some level of automation in the calibration process, allowed the team to create a 200-equation model that represented the initial dynamic hypothesis and was roughly calibrated to high-level variables.

The model calibration process showed that one feedback link, considered secondary in the conceptualization phase, in fact had important implications for the speed with which product diffusion occurred in the early years of service. Although the long-term valuations were not radically affected by this change in the model, it was an important insight to be considered in uptake expectations for next-generation services, and it

implied that the company had significant control over eventual service penetration. This discovery also increased the credibility of the client team in the ability of a quantitative model to improve their understanding of the market.

3) **Model-based analysis and strategy exploration**: The last two weeks of the engagement focused on further model testing and in answering four questions identified in the conceptualization phase:

   a. Where is the market saturation point for the service?
   b. What is the impact of low-cost technologies and regulatory changes on business value?
   c. What pricing strategies would maximize the value of the operation?
   d. How should the business model change to take full advantage of this shift in strategy?

While the model captured only a subset of the overall industry blueprint, we made use of sensitivity analysis to explore exogenous assumptions. Current simulation software makes it feasible to quickly test a wide range of options (either using grid search or Monte Carlo techniques) around pricing combinations, regulatory changes, and the uncertainties of new technology impacts. We also explored best and worst-case scenarios for each of the questions, to provide management with a realistic range of outcomes.

A key insight for management during this phase was the power of changing multiple business levers simultaneously. Conventional thinking held that it was not possible to extract much value out of low-income customers, which represent about 80% of the total population in the market. A small group of managers, however, held a contrarian view: that capturing customers in the low-value segment would be profitable over the long run, if only the right mix of product and pricing was found.

Using the model, we explored thousands of product and pricing combinations until we found the set of strategies that maximized value. Figure 3, for example, shows an example where the combined effect of two strategy levers reverses their individual effect on long-term value. The result was an opportunity to increase shareholder value in the range of $500M-$1.5B through a radical redefinition of the business model. The potential size of the stakes, even when considering aggressive competitive responses, made it clear to managers that the market still had substantial upside, and that dynamic simulation could help them make the transition to a profitable business model for the next ten years.

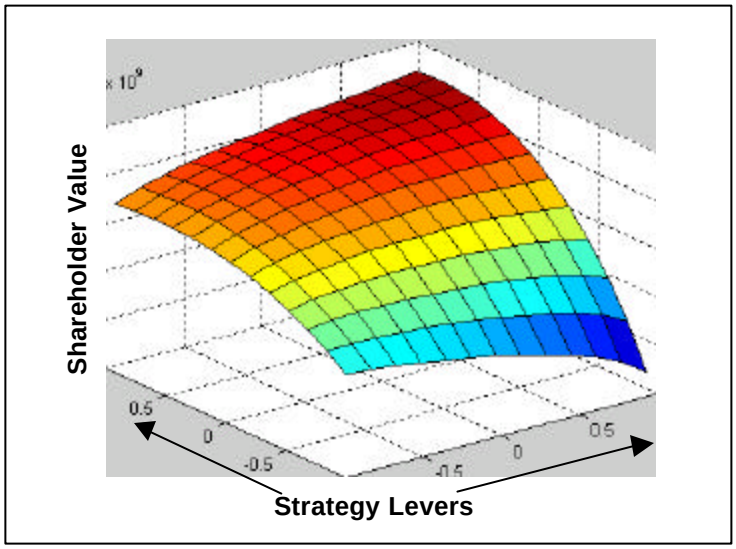

Figure 3. Surface of value created by 2600 alternative pricing strategies

III. Twelve tactics to improve on the expected tradeoffs

The lean approach described in the previous section shows that it is possible to maintain scientific rigor even under an accelerated schedule.

For the first stage (issues definition and prioritization) the dynamic hypothesis is qualitative, specifically embodied on causal diagrams and sketches of behavior over time. The test of its validity is its ability to capture and describe the drivers of issues that key stakeholders consider relevant. As we move to the second stage (quantitative model development) the hypothesis is formulated as the model equations, and the calibration process serves as testing. The third stage (model-based analysis) focuses on testing whether the model is able to generate plausible numerical answers to the strategic issues faced by the client. In each stage, if the hypothesis is initially rejected then it is refined until all available facts can be explained to the satisfaction of the experimenters (in this case, the model builders and workshop participants).

This level of rigor in model building is necessary if the model will be used to provide answers to high-level strategic questions. However, to reconcile the rigor with the time constraints of the engagement, it is necessary to apply tactics that accelerate modeling without sacrificing quality. We have identified twelve tactics grouped under three main categories: advance preparation, lean model architecture and lean interaction with the client. We describe each in turn.

Advance preparation

The lean approach requires that modelers hit the ground running. Preparation makes the team conversant with the client's issues, and also gives additional time for planning and design. This

upfront investment translates in lower modeling rework as the engagement advances. Four tactics are critical for thorough advance preparation:

a. *Prepare the executive team for the task ahead*: A critical success factor for a short strategic effort is access to people and information in the organization. Our internal coach met with key managers before the first workshop, and invited some of them to the discussions. This accelerated the information gathering process over the following weeks.

b. *Start modeling prior to first workshop*: Qualitative modeling started from day one. By the time the first workshop started, a second-generation causal loop diagram with most key factors was available for the group, the result of an internal consulting team iteration and a session with our coach. This focused the workshop discussion only on the areas that related to decision rules, and on questions about model boundary and levels of aggregation.

c. *Perform substantial exploratory data analysis*: Accurate historical reference modes were available early on for many variables. This allowed the modeling team to explore different hypotheses about cause and effect that could not have been generated without the help of data. Many of the hypotheses could be discarded by simply analyzing data trends, avoiding lengthy sessions dedicated to recollections and model testing.

d. *Solve data inconsistencies before quantitative modeling starts*: The data collection process is never perfect: for example, revenue figures for a next-generation service were mixed during its first year with revenues from the existing service, creating an artificial spike in demand. We discovered this inconsistency and obtained an explanation for it in the second week of the engagement, well before starting to generate structural explanations for a data artifice. Similar problems were found in other places, such as costs or usage data. Not all of them were solved to satisfaction, however; part of the "leanness" of the approach relies on the discipline to prioritize which aspects will have a material effect on the answers sought, and try to resolve only those that meet this criterion.

Lean model architecture:

A model that represents with great realism and detail the feedback structure and decision-making rules of the system will not be feasible in a six-week project. In real terms, only about 2 person-weeks are available during the engagement for equation writing and debugging. Therefore, there should be a clear understanding of both the model boundaries and the model content to make sure that it answers the top questions with the simplest structure possible. The following tactics are useful to achieve the lean architecture goals:

e. *Guide boundary definition by need for answers, not number of loops*: While feedback is one of the key differentiating aspects of system dynamics, having more loops in a model does not necessarily make it better (one could argue that it makes it worse by reducing the user's understanding). Instead of counting the number of loops present in the

quantitative model, we focused on building a model that was capable of answering the questions posed to the team at the engagement's start. That meant severing loops and making exogenous sectors that were not critical for the answers requested (for example, decisions around choice of marketing activities).

f. *Use the Causal Loop Diagram as a blueprint, not a commitment*: Probably the most important outcome of the first workshop is the agreement that the causal loop diagram is a blueprint of a more detailed, quantitative model, which would be built in phases. There was no expectation that the first quantitative model would capture all potentially relevant feedbacks in the system. The challenge is that the client is still expecting a model to represent realistically their position in the industry; this was possible by defining a wider band of confidence for the results and constraining the kinds of scenarios and analyses that the model could support.

g. *Use previously-developed structure to keep the modeling simple*: Paradoxically, building large, calibrated models in similar industries provides excellent guidance for identifying the smallest number of equations needed to answer a client's issues. Questions asked to strategy models tend to be fairly constant (pricing, resource allocation, competitive actions, market sizing, etc.), and as a result we have developed a knowledge base of structures proven to work in these applications. This means that the model structure will need less testing in order to be a useful representation of the system in question, and at the same time it will probably be simpler than one developed through an inclusive, consensus-driven group modeling effort.

h. *Add and Calibrate module-by-module to achieve early diagnosis*: We start building the simulation model with single modules of structure that can be calibrated immediately, with either data or estimates for key inputs. We did not have to wait until feedback loops were formed to start calibration. The increasing ease in data manipulation and the speed of calibration achieved with automated techniques allowed us to have a model that from very early on shows realistic behavior, and where divergences between behavior and data can be quickly resolved. Model testing focuses more on making sure that reference modes are matched for the right reasons.

Lean interaction with the client:

Using system dynamics to answer strategic questions means that the client is, first and foremost, interested in results. A lean relationship means that most client interactions should emphasize results, as the following four tactics indicate:

i. *Build a strong relationship with an internal coach*: Having a member of the client organization that is familiar with System Dynamics can help clear barriers and accelerate information sharing. We were fortunate to find a client that was already familiar with our approach, and willing to act as a coach to give us access to the issues in the minds of the managers. Even if this is not present from the start, it is advisable to try to find a member of the client organization that can act as a translator between managers and consultants,

ideally somebody that finds the modeling approach appealing and that has a certain degree of seniority in the organization.

j. *Enhance credibility through numerical validation*: A consequence of maintaining a model always roughly calibrated is that we overcome a credibility hurdle. Corporations are results-driven, and missing estimates can be costly. Managers, therefore, regard numerical accuracy as a critical validation test, and a model that does not comply with this criterion runs the risk of being regarded as incomplete, or just plain wrong, regardless of its methodological merits. Having a model calibrated early on in the process, even when some portions of the structure were absent, opened the door to very fruitful discussions about the sources of behavior.

k. *Minimize number of formats for model information*: Richmond (1997) describes causal loop diagrams, stock-and-flow diagrams and model equations as three different languages, which must be understood by model process participants before useful results can be achieved with them. A lean interaction with the client requires that we deliver system dynamics concepts in a very consistent way – explaining the theory and "etymology" of the different languages in each stage makes the process much slower, frustrating stakeholders that have an interest to get results as quickly as possible. We emphasized verbal communication, causal diagrams, and time plots during the process, telling dynamic stories about the sources of behavior (Mayo et al. 2001). We made little use of stock-flow diagrams and equations.

l. *Add value in each meeting, and have just a few meetings*: The client was initially concerned about the cost and effort of bringing consultants up to speed. By bringing industry experience to the table, we were able from the start to focus client interactions on understanding their plans, and sharing with them results from analyses, accomplishing in just two workshops (and two more meetings with our coach) what is usually achieved after a much broader interviewing process.

IV. Conclusion

It is possible to answer high-stakes strategic questions with a six-week effort. A lean approach can use a roughly calibrated medium-sized system dynamics model as the basis for experimentation and testing.

Is it possible to apply such a lean approach in any strategy engagement? Not always. For example, Mayo et al. (2001) describes early discussions around the privatization of London Underground; the complexity of the options required 8 weeks of qualitative modeling before any quantitative modeling could start. Graham and Ariza (2001) describe a case where the combinatorial complexity of interactions between different product lines made a detailed model indispensable to make useful recommendations on resource allocation options. In these two cases, a lean strategy model can be a great first step, but it will not answer the most important strategic questions for the client. So it is necessary to qualify the type of client and the type of

question to make sure that the lean approach will deliver the needed value. Some characteristics that improve the odds of success are:

a. Relatively homogenous and therefore aggregatable product or service offerings.
b. A small set of key issues, which could be framed as "go/no go" options.
c. Access to key stakeholders.
d. Previous modeling experience in similar industries.
e. Client enthusiasm for model-based approaches to strategy.
f. Access to historical data on short notice.

The current processes and technology also place limits to how "lean" a modeling engagement can be become. We believe there are at least three areas where further improvements would benefit a lean approach to modeling:

a. Automatic data input and calibration.
b. Software support for easier structure re-use.
c. Refinement of templates for data collection and structure blueprints for a variety of industries.

A leaner approach to strategy modeling can add substantial value by accelerating the delivery of quantitative results from a System Dynamics model. As always not all strategic questions can be answered with precisely the same approach, so the modeling team should take into account the client and problem characteristics and design a modeling process fitting the situation. What the present case does prove is that an opportunistic approach to designing the leanest feasible modeling process can yield speed, validity, value, and buy-in that substantially exceed a standard "one size fits all" approach.

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