"DEVELOPMENT OF A CASUAL USER INTERFACE FOR SIMULATION MODELS"

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ABSTRACT

One of the traditional obstacles to effective utilization of simulation models has been the great deal of time spent learning languages in which models are written and keeping track of the specific variable names and equations within models. To remove this excessive psychological burden from busy executives and to refocus attention towards the actual behavior being replicated, Inter/Consult has been researching development of highly supportive user interfaces to models. These interfaces prompt users by stating the nature of the model's assumptions then asking what changes they would like to make. Through this on-line question-and-answer dialog users can build and compare scenarios without prior knowledge of computer languages and mathematical formulas or specific model components.

Our paper presents reactions to the interface by members of the graphic arts industry who have used it. We discuss further improvements which are being made to the interface to make our models more accessible to non-expert users. Finally we explain why we feel that tightly-focused, easy-to-use, dynamic simulation models are of invaluable benefit to any industry such as graphic arts where craft-oriented skills are being replaced by rapidly evolving new technolgies.

INTRODUCTION

We feel it is vitally important that executives from varied backgrounds take advantage of the insights which can be gained through use of simulation models -- comprehensive tools which integrate different assumptions and perspectives on industry trends. A simulation model can act as a nexus which combines different members of a strategic planning committee's views into a single scenario.

The interface which has been developed for "TECHNOLOGY DYNAMICS" models allows users to easily work with our models while spending less time studying the model's operations and more time analyzing behavior and establishing policy. A clear understanding of the workings of models at the conceptual level is absolutely essential for their effective use, yet detailed knowledge of model structures or internals is not. We recognize that major efforts must be made to determine the nature of relationships within simulation models, yet we strongly feel that as more people become involved in that process results will be improved. Our overriding goal in the development of the interface has been to increase the number of people manipulating and examining our models.

Our first interface was built around Inter/Consult's model "The World of Electronic Color", adapted from the Image Assembly

System model. The research that produced the Image Assembly System simulation model was funded by a grant from Inter/Consult, through Professor John Morecroft's Corporate Research Program at the Sloan School of Management of the Massachusetts Institute of Technology. The modeling was done by David Kreutzer and Robert Lucadello, with important design advice from Dr. Alan Graham, and reported in "Strategies for Investing in Electronic Color".[1]

This first application of TECHNOLOGY DYNAMICS deals specifically with color image assembly or page makeup systems. These million dollar plus systems are now revolutionizing the process of preparation of printing plates for color magazines, books, and catalogs. The TECHNOLOGY DYNAMICS model is helping potential purchasers to evaluate alternatives about when and how to automate their color prepress production. It also serves the needs of systems and material suppliers who must understand how technology maturity, price, industry structure, system capabilities and user field experience will interact to affect the evolution of interactive color assembly systems marketed in this decade.

WHY DYNAMIC MODELS

Selection of electronic color systems is currently based on some mix of data, expert opinion and intuition, yet the potential

consequences of such a decision suggest that better methods for strategic planning are needed. Rarely are any but the largest companies able to consistently and comprehensively monitor industry developments in an organized fashion so that their decisions are based on the most recent technological data.

Unfortunately, the current state-of-the-art in market and technological forecasting for the color separation segment of the graphic arts industry is comparable to the agricultural industry when its principal forecasting tool was the Farmer's Almanac. In response to this critical situation, Inter/Consult has designed and developed TECHNOLOGY DYNAMICS to assist industry decision makers in the critical process of planning for the changes of the next decade.

TECHNOLOGY DYNAMICS emerges from Inter/Consult's work over the last three years on resolution of the problem of integrating all we know about trends in technologies with our market research on the size of potential markets for new products. Its purpose is to serve as a tool for achieving a better understanding of the industry and for evaluating alternative corporate policies. Much of the groundwork on Technology Dynamics methodology was done in our study, conducted with the Institute for Graphic Communications, entitled, "The Future For Electronic Pagination,"[2] which was published a year and a half ago. The study's results and methodology were highly effective, but lack of time and our inability to find suitable computer-based modeling tools limited us to use of ordinary statistical analysis packages and hand calculators for actual forecasts made in that study.

TECHNOLOGY DYNAMICS addresses what we at Inter/Consult have come to call the failure of forecasting. Traditional market research techniques in the mid 1970's showed themselves unable to cope with the rapid change in products and market shape induced by the emergence of the microprocessor. Econometric models are excellent forecasting tools in situations where historical market data provides a good indication of the pattern of future market growth. In situations where product structures and market conditions are changing drastically within short periods of time, however, new and more intelligent forecasting methods are demanded. System Dynamics models are uniquely designed to replicate behavior of systems which are undergoing change. Certainly no one would argue with our contention that graphic arts and other skilled, labor-intensive markets being automated by computer technologies will see tremendous changes within the next few years. These will affect the competitive enviroment, products produced, the way that value is added and the industry demographics. Old competitors will die and new ones will emerge.

When studying emerging markets, forcasters must not only take advantage of traditional economic theory and practices, but also draw upon survey techniques developed in the field of sociology and cybernetic theories from engineering disciplines. According to Forrester, "In modeling economic behavior all kinds of information should be used, not merely numerical data. Rich stores of information about economic structure and governing policies are available from mental data bases built up from experience and observation."[3] System Dynamic models provide a computational environment where nonstatistical information has a meaningful context; the TD user interface allows it to directly tap the vast mental databases of experts and decision makers throughout the graphic arts industry.

Another attractive aspect of the System Dynamic approach is that it attempts to deal directly with the interconnected feedback loops which combine to form systems and impact market behavior. "It takes the philosophical position that feedback structures are responsible for the changes we experience over time," wrote George Richardson and Alexander Pugh.[4] We at Inter/Consult have spent a great deal of time pondering the eventual outcome of related events in the evolution of markets for computer graphics equipment. We have witnessed the learning curves which vendors, service businesses and, eventually, end-users go through when major breakthroughs in computer based production are introduced in printing and publishing environments. We are convinced that a systems approach which anticipates the eventual maturing of revolutionary products is necessary for strategic planning in situations such as this.

THE PROBLEM

The new electronic color technology has become the driving force behind a dramatic evolution now visible in the color separation industry. Traditional color printing preparatory shops and the lithographers they historically served are now able to purchase digitizing scanners and electronic color page makeup systems with direct computer-to-plate output to automate their operations. The resulting displacement of traditional skills and of the labor-intensive craft orientation creates a potential for rapid change in the structure of the industry. These systems also necessitate a previously unheard of consideration for industrial participants, the assessment of long-term strategic implications of the decision to purchase computerized production equipment.

Executives responsible for evaluation of electronic color systems must not only assess the current state-of-the-art but also determine whether future products will be faster, more capable and/or less costly. Strategic planners must determine

whether the timing of competitors' investments in new production technology will force them to move faster than they might wish to. A. E. Gardner writes, "Contemporary decision making must now be done within the context of a complex, rapidly changing confluence of technological and unpredictable economic considerations."[5]

Innovative electronic systems have already altered the rules of the competitive game in the color separation industry. As the capital cost of the highly productive new systems falls over time, acceptance by existing companies will inevitably lead to overcapacity in the sector. Moreover, low entry cost in capital and operator skills will attract new corporate competitors. Finally, as opportunity and operating costs fall even lower, those businesses which once purchased services in the open market will instead acquire their own in-house production capability. This destabilizes the existing supply and demand economics of a service-based industry. It forces dramatic changes in the pricing, profit margins and customer profiles of the service-oriented sectors. Experience in markets which previously survived the complete cycle of automation like commercial typesetting and newspapers indicates that there is a complete restructuring of the in-house, service and captive sectors of a market which sustains this type of transition. To quote Ephraim

Arazi, president of Scitex Corporation, the new electronic systems "open up entire new markets and change the traditional boundaries between sectors in the printing and publishing field."

THE MODEL

The "World of Electronic Color Model" incorporates six major sectors. These address technological trends, vendor issues, and market conditions, as well as the concerns of customers, individual firms within the industry and new entrants.

The Separation Industry Electronic Capacity Sector emulates the displacement of craft operations by digitized systems. As the price and performance of equipment improve, the number of units sold and installed increases.

The Electronic Color System Vendor Sector models the behavior of system vendors. Changes in price and performance of systems directly affect acceptance of systems by users in both service and in-house situations.

The Color Separation Market Sector emulates the mechanisms of supply and demand which determine the open market pricing and profit margins for jobs performed on a service basis.

The Customer Sector traces the movement of work into and

out of the market. It examines the relative costs of alternatives to color printing and considers the long term demand for color pages.

The Individual Firm Sector takes real-world data from industry sources or from the actual users of the model and emulates the operational and financial life of the individual company competing for market share on a service basis. The firm's operating cost and utilization of its capacity, debt load, investment rate and pricing of service all translate into a determination of its market share and profit.

The Competitors and Inplant Operations Sector models the purchase of systems by in-house operators as described above. In conjunction with the Color Separation Market Sector, it provides model users a way of emulating the changes in customer base, service demand, pricing, profitability and industry capacity which occur over the maturation of a technology displacement cycle.

Although this model specifically focuses on color page makeup, other industries which are being impacted by new technologies have similar structures and exhibit strikingly similar behavior. We are presently developing a model which deals with electronic technical publishing systems as part of a three volume study sponsored with Printing Industries of America. These systems involve the integration of word processing, data processing, Cad/Cam, and computer graphics with traditional in-plant printing, composition, typesetting, and electronic or laser printing systems. Integrated Electronic Technical Publishing systems are being designed to handle the majority of corporate information requirements.

THE INTERFACE

The concept of TECHNOLOGY DYNAMICS is that users feed in their own views on industry trends which may or may not be the same as the base run assumption provided by us. The goal is development of internally consistent scenarios on how the color systems ratio of performance/cost will evolve and how the markets for them will develop. The connection between the dynamic model and the user is in real time on a black and white video terminal, with a dot matrix printer for on-demand hard copy. Output can also be sent to a remote 4-color pen plotter or laser printer.

In designing the TD interface , several specific interests were considered. The primary driving force in the implementation approach was that all of the assumptions that comprise the model should be spelled out in plain English. Second, users ought to be able to change those assumptions through a dialog with the model in English. Finally, output from the model should be available

immediately and should be easily understandable without knowledge of Dynamo or host system conventions.

We felt that top decision makers would be more likely to use the model if they could concentrate on its content without learning about its programming structure. Thus we translated the majority of the model's equations into sentences. The user can examine the various assumptions by going through a tutorial online questionnaire. We segmented the questionnaire into sections which roughly correspond to the sectors of the model's flow diagram. This allows people to address their specific concerns without having to wade through a great deal of extraneous information.

Each statement of the model's assumptions is followed by a question as to whether or not the user agrees with it. In instances where the user disagrees with our base run he or she is prompted with questions about what the "correct" assumption is. The interface then converts responses into Dynamo rerun statements.

This approach limits the casual user to making changes which can be replicated in rerun statements, yet we have found that 90% of the types of scenarios our clients want can be generated through the interface questionnaire dialog. Where structural changes to the model are desired, someone with a detailed understanding of both the model and Dynamo must make them.

On the output side, the interface asks which variables should be plotted or printed for given reruns. Once again the dialog is in English with answers being interpreted for Dynamo. There are several options for type of output. Dynamo plots and tables of data can be sent back to the terminal in which case the interface formats the output so that an entire plot will fit on the display screen. The same plot can be automatically enlarged for output on an 8-1/2" by 11" page to be printed locally via a printer attached to the terminal or sent to a remote laser printing device. If higher quality images are desired the interface will drive a remote color plotter creating line graphs from the tabular data Dynamo produces. Here the size of the resulting graph can be specified along with the type of paper and ink to be used. A major benefit of this method is that graphs can be given descriptive labels identifying their origin and content.

The next area of interface development involved tailoring it to the amount of experience of each user. We began by creating three levels; beginner, intermediate and expert. Beginners are given full paragraphs and sometimes pages of explanation of assumptions. In addition to being a way to run the model this

makeup systems and markets. The intermediate level provides shorter pieces of information, generally one or two line definitions of underlying assumption. While the expert level is for those who know the model and Dynamo. In order to facilitate fast access by proficient modelers, brief phrases are used to express the meaning of dynamo equations. Responses are confined to numeric changes of model parameters.

An additional aspect of the interface is that it provides a trail of rerun information that is placed in a historical file for each user. Reruns can be recalled from the day before or any other prior work session. As a result users develop and maintain their own set of scenarios making adjustments only to their tailored versions of the model. Many bookkeeping and database headaches are eliminated in this way.

We are currently developing a version of the model which will use a color video display and quantitize or interpolate the dynamic model results. These will then be fed directly into a financial forecasting model. The end results will be profit and loss forecasts and discounted cash flows for potential system buyers and market forecasting or market strategic analysis data for suppliers. Eventually TECHNOLOGY DYNAMICS will include routine updates of key industry statistics with full real time color interaction for scenario generation and direct links to other packages for production of the reports.

THE REACTION

Thus far the response to both the interface and the model has been overwhelmingly positive. People appreciate the model as a means of analyzing the complex issues involved in prepress automation without having to study the intricate lines of code which comprise it. Users come away genuinely pleased after inputing scenarios which they had been considering prior to exposure to the model but had never been able to spell out clearly for their peers to see. Even the more conservative members of the graphic arts community who are fundamentally opposed to implementation of electronic prepress color systems have found comfort in their ability to have their beliefs tested and compared to those with more divergent, more optimistic opinions. While few completely comprehend the full power and advantages of dynamic models almost all of our users perceive the value in logically replicating the behavior of their markets using their own assumptions.

The color printing business is an extremely subjective one. It is very difficult to learn how to produce quality work cost effectively. It takes a well trained eye to interpret what a customer means when he says, "I want a friendlier blue". Our

clients feel that "The World of Electronic Color Model" increases their objectivity and has made a positive contribution to the graphic art industry. In a recent letter Zane Tankel, president of Collier Graphic Services and an early user of the model wrote, "We did find your input most helpful and are certainly appreciative. Hopefully, our input back to you was equally helpful. I think there is a most definite need for TECHNOLOGY DYNAMICS and your computer model is something more people should take advantage of prior to acquiring any computerized imaging system. It would certainly be time and money well spent." Tankel points out another heretofore unrecognized benefit of creating a friendly interface to Dynamo. As a consequence of having experts from printing businesses use the model we do indeed find their input equally helpful in strengthening our understanding of what is occuring in the industry. The development of the model itself has been an iterative process for us. Where we see consistent disagreement with our base run assumptions by knowledgeable users, we further refine the model to more closely reflect actual behavior patterns. The cumulative experience of our users has unquestionably been our best teacher.

THE CONCLUSION

This is an example of the kind of analysis that we can, through TECHNOLOGY DYNAMICS, provide potential buyers of very through TECHNOLOGY DYNAMICS, provide potential buyers of very expensive and rapidly changing systems. However we must hasten to point out two things. First of all, this is not a crystal ball. It is a strategic support tool to help decision makers do things that they do in their head already, but a little bit faster, a little bit better, and in a way that's a little bit more shareable with others involved in making the decision. Second, the work of getting this kind of tool into the hands of managers has only begun. More advanced and user-friendly interfaces are both necessary and possible. At some point in the future users should be able to merely speak to dynamic models and have them respond. We feel TECHNOLOGY DYNAMICS and computers in general must become "people literate" rather than vice versa.

TD is a new approach to the problem of strategy development and assessment relative to the displacement of traditional means of production by computerized systems in a craft-oriented industry. This kind of modeling will be a useful tool for users and providers of the new technologies.

ABOUT THE AUTHORS

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