Planning via System Dynamics Models; Strategy Dynamics of Market Evolution

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Abstract

Realizing the importance of developing an integrated approach for effective Product Life Cycle (PLC) Management this paper examines the use of the system dynamics approach to capture the market evolution structure. After going through a review on Product Life Cycle Management and the System Dynamics approach a holistic model of market evolution is developed involving the most important components of the business environment problem situation such as the buying process, PLC characteristics, Customer Satisfaction and plausible Marketing Strategies. The model is further assessed on a number of dimensions such as its ability to emulate the evolution of the product through the stages of the PLC, and the ability of the model to provide valuable information for formulating effective strategies.

Keywords: Strategic Management, Product Life Cycle Management, Planning Models, System Dynamics

Introduction

The increasing complexity of the organizational-environmental problem situation presents a great challenge for today's managers. The fact that market continuous evolves for almost all products calls for new approaches in managing Product Life Cycles, which take into consideration the many interdependent parts, which continuously change over time. Two components appear to be especially crucial in such an integrated approach: the structure of the organizational system and the steering possibilities or decision rules that the organizational structure allows. High complexity though arises as system structure exhibits all its possible observable manifestations in many variables having their roots in the patterns of interaction between important components of the system. To deal with the high complexity we need to take a perspective for the role of strategic management as that of reducing the uncertainty of these variables, which operate between organization and its environment and ensure the organization's continuous adaptation in new business situations. Further, a high priority task is the identification of favorable or unfavorable configurations of the structural elements showing a high intrinsic steering capacity, hence increasing the governance of the system under study. Normally, favorable configurations of the structural elements manifest themselves in desirable outputs, resulting from the patterns of the interplay between the most variables.

Different configurations produce different patterns of interactions between the relevant variables and give rise to different values of the defined and quantified performance indices. Modeling the relevant structures and undertaking experimental simulations capable of anticipating these patterns becomes the appropriate methodological tool for developing strategies and steering information, capable of securing survival and development of the organization. Structural configurations are in a continuous interaction with the environment. This invalidates any static view to strategic management and forces us to link structure to behavior in a dynamic system of continuous interaction between the important structural variables. In this way we may construct system models and study satisfactory approximations of the real system's path over time. Any serious planning methodology has to account for this simple principle before its deployment.

Different modeling schools, following their selective perspectives, embark on research having the intention to enhance diagnostic and design abilities. Regardless of the perspective engaged, the effort is always to learn, i.e., through a generation of simulated variations of behavior to select and retain the most promising patterns, that secure a viable orientation. Two problems appear in all modeling schools though. First, the problem of validity, i.e., degree of correspondence of the model to the real system so that all relevant factors are considered so that the system under study does not enter a strategic drift caused by selective blindness. Second, the problem of eliminating cognitive overload, that is, holding the variables and steering levers of the model within manageable boundaries. These variables should be held within the limits of human information processing capacity, without however, omitting essential parts of the real system. Both problems are of immense importance and have to be resolved for the development of a reliable, effective planning methodology.

In a recent book prepared by Niemann *et al* (2009) as part of European funded research project the design of sustainable product life cycles is examined. Here the importance of a holistic long-term approach to Product Life Cycle management is emphasized. Especially it becomes vivid that various methods and tools for life cycle management need to be merged into an integrated planning approach. Sharing the concern for a holistic approach this paper investigates the system dynamics paradigm for effective PLC management.

The paper reviews the deployment of the system dynamics approach to develop a market evolution model whereby strategies can be developed for effective Product Life Cycle Management. The model is generic in nature and it can be used in a variety of organizational-business situations with slight variations. The model is created in order to strike a balance between validity and simplicity and applicability. As shown in this paper the model is assessed on a number of check points for effective Product Life Cycle Management which include; its ability to define the product-market problem situation as a set of interrelated components of people, data, organizational process and business elements; ability of the model to emulate the evolution of the product through the stages of initiation, growth maturity and decline; the ability of the model to establish the position of the firm's product in relation to its life cycle and the market; ability of the model to forecast key parameters, such as the magnitude of sales, duration of stage and shape of curve; ability of the model to provide information via the PLC for formulating effective strategies.

The next section reviews the problem of market evolution and the key data available by the Product Impact on Market Strategy (PIMS) database. This is followed by a review of system dynamics as a strategic planning tool. Further on the market evolution system dynamics model is developed and assessed on its validity and applicability to support effective Product Life Cycle management. Finally, conclusions are drawn with possible future research directions.

Market Dynamics and Evolution Theory

This paper focuses one of the most important business problems at the market level, which is the one of substitution which takes the form of new product diffusion (Bass, 1969; Bass, 1986). Out of these two observed phenomena we get a variety of management implications. Technological substitutions normally cause the emergence of new value potentials and hence the need for defining new business models, core competencies, and strategies. These in turn, bring the need for reengineering the established processes in order to build the new required value potential. The variety of management problems involved in market dynamics can be summarized as follows:

- failing to recognize the degree of market saturation for the product, as a derivative of the expected maximum potential
- failing to recognize the beginning of a substitution process

- failing to recognize changes in technological trends

Empirical evidence available to give us insights in addressing the above planning mistakes can be found in the PIMS (Profit impact of marketing strategy) database (Buzzell, and Gale, 1987). The PIMS database includes three different indicators for the stage of evolution for each business unit´s served market: its age, that is when the products or services were first marketed, its growth rate, and the management's assignment of the market to one of the four conventional PLC (Product Life Cycle) stages. As PIMS researchers openly admit that no system of classifying markets by stage of evolution is completely satisfactory, the acceptance of the PLC stage designations should be made by the strategic business unit manager.

Businesses operating in mature markets represent over 70% in the database and they are subdivided into three groups: growth maturity that have annual growth rates of 5% or higher, stable maturity, that have growth rates of 5% or higher, stable maturity that have growth rate between -5% and +5% and declining maturity that have 5% at least. PIMS findings also refer to configurations of several variables, which include growth rate, inflation, concentration among suppliers, purchase amount and importance of product to customers, employee unionization and magnitude of imports and exports. These could make a market unattractive being the last favorable fifth in the database on each dimension, attractive, which is a business whose market ranks in the most favorable fifth, and average, that is, average scores on each market/industry factor in terms of expected ROI. Return On Investment is ranging from 10,6 % for average unattractive, 22,4 % for average and 35 % for attractive. These configurations could thus be used to select a profitable competitive arena.

The obvious conclusion is that most of the given variables values are symptomatic and they do not reveal the underlying factors that determine the parameters of the product life cycle and market evolution. These symptomatic values could offer the modeler the capability of comparison with real data for the purpose of verification and validation of the elsewhere derived causal mechanisms responsible for generating the quantified symptoms. Therefore other empirical theories should be utilized in order to efficiently address the problems of informed forecasting and suitable strategy development.

Distinctive contributions to the long-standing controversy over the managerial value of the Product Life Cycle (PLC) concept are to be found in the seminal work of Day (1981). A more recent approach to Product Lifecycle Management (PLM) argues for integrating people, data, processes and business systems and provides a product information backbone for companies and their extended enterprise (Grieves, 2005). On the conceptual front, the work of Day (1981) clearly defines the five basic issues that must be resolved in any meaningful application of PLM. The first issue concerns how should the product-market be defined for the purpose of life cycle analysis. Then factors should be identified that determine the evolution of product through the stages of an initial trajectory stage, over to a transition in rapid growth, maturity and then decline. Next, the PLC position should be unambiguously established. Further the potential for forecasting key parameters, including the magnitude of sales, duration of stage and shape of curve should be determined. Finally, the role of the PLC concept in the formulation of strategy should be clarified. These questions will be used as check points in order to assess the applicability of a market evolution system dynamics model developed in this paper.

The five issues to be resolved according to Day for effective Product Life Cycle Management are outlined below. In this paper a system dynamics model of market evolution is developed and is assessed based on these questions.

1. How should the product-market be defined for the purpose of life cycle analysis?
2. What factors determine the evolution of product through the stages of an initial trajectory stage, over to a transition in rapid growth, maturity and then decline?
3. Can the present PLC position be unambiguously established?
4. What is the potential for forecasting key parameters, including the magnitude of sales, duration of stage and shape of curve?
5. What role should the PLC concept play in the formulation of strategy?

Resolving the above issues would give us guidelines for specifying structure, extract mathematical characteristics and connect this structure to expected behavior. As a result through computer simulation we could arrive at insights drastically increasing chances for avoiding planning mistakes. What we are seeking for are generic structures containing invariants that can be quantified in stocks and flows, and mainly parameters that consistently produce the empirically found patterns. Hence our proposal in this paper is that through System Dynamics modeling and simulation we should be able to develop effective strategies in evolving markets. This thesis will be examined in following two sections.

System Dynamics as a Modeling and Strategic Planning Tool

The primary assumption of the system dynamics paradigm is that the persistent dynamic tendencies of any complex social system arise from its internal causal structure. Thus, if a model is to indicate the effect of real system changes, there must be a correspondence between the parameters and structure that could be changed in the system, and the parameters and structure of the real system. The mechanisms of the model must then represent mechanisms of the real system, so that the model is capable of generating the direction of the major changes in system performance. In such a case, performance is not taken to mean the prediction of the future system state and the exact numerical values of variables, but generating the behavior of patterns and dynamic tendencies, such as stable or unstable, oscillating, exponentially growing, self-correcting or in equilibrium. For instance, a system dynamicist will rather be interested in profitability and cash position variations than the exact numerical values of a projected cash flow. The interest is on the pattern of company growth such as oscillating, or declining. Also important is the degree of market penetration, and not the exact market share of the company at a future point in time. In general, the interest is on those characteristics, belonging to a meta-logical level, which indicate the desirability of system states modeled by computer simulation.

The central idea that system dynamics uses to understand system structure is the two-way causation or feedback. It is assumed that social or individual decisions are made on the basis of information about the state of the system or the environment surrounding the decision maker. The decisions lead to actions that are intended to change the undesirable or maintain the desirable state of affairs. New information about the system state then produces further decisions and changes. The circle is continuous and each such closed chain of causal relationships forms a feedback loop. By definition then, system dynamics models are made up of many such loops linked together, and are basically closed-system representations in which most of the variables occur in feedback relationships and are endogenous.

Peter Senge in a recent speech described organizational life as a web of interdependencies, which can be represented by the various feedback loops in a system dynamics model. These ideas are vividly illustrated in Senge *et al* (2010) where a number of case studies are provided involving well-known companies such as Coca-Cola and Nike as to how individuals and organizations could work together to create a sustainable world. Understanding and managing this web of interdependencies should be the goal of an effective strategic management approach.

The system dynamicist recognizes that noise, represented by random events whose source is outside and independent of the real system can take an unpredictable form and have unknown influences when compared with orderly forces, like observed regular time-series. Such random events could be the uncertain influence of weather, local, national or international political news or measurement errors. Thus, commitment should be given to models in which every decision function has, at least in principle, a noise uncertainty component. By definition the exact time pattern of this noise is unknown but there exist useful estimates of its magnitude and statistical characteristics. The model acts on the noise components as it acts on all other flows within the system. The structure and characteristics of the model determine the nature of the reaction to the noise. Not knowing the instantaneous values of noise, does not obscure the study of the kind of behavior exhibited by the system, including the sensitivity to the noise inputs. This sensitivity can be experimentally established by changing the noise random seeds in computer simulation.

Feedback processes do not operate instantly; the timing of system behavior depends on elements that create inertia or delays. Information about action is not immediately available. Decisions do not respond instantaneously to available information and time is required for executing actions indicated by a decision. These accumulations or inertial elements that could describe the state of the system when every activity stops, are the levels or stocks, and they can be of material form or information. Typical material levels are capital stock, inventories, cash balances. Levels of information can be perceptions like quality indices, or knowledge and cumulative learning. Levels enable or inhibit actions, functioning both as resources and constraints.

System elements representing the decision, action, or change in a level are called rates. A rate is a flow of material or information to or from a level. Examples are investment rate, rate of hiring, rate of potential customers becoming interested, and so on. Rates define the present instantaneous flows between the levels of the system. They correspond to activities, while the levels measure the resulting state to which the system has been brought by the activity. The rates of flow are determined by the levels of the system according to rules defined by the decision functions. In turn, the rates determine the levels. The levels determining a particular flow rate will usually include the level from which the flow itself comes.

The representation of a system by means of feedback, levels and rates requires a careful distinction between stocks and flows of real physical quantities and of information. In the system dynamics paradigm physical flows are constrained to obey physical laws such as conservation of mass and energy. On the other hand, information does not need to be conserved, it may be at more than one place at the same time, it cannot be acted upon at the moment of its generation and it may be biased, delayed, amplified or attenuated. Since information is the raw material of decisions, information distraction must be included in the model, if we are to represent decisions properly. The principle of independence of decisions, applicable in practice, makes possible a formulation that is free of simultaneous algebraic equations.

Two kinds of feedback loops are distinguished by the system dynamicist: Positive loops which tend to amplify any disturbance and to produce exponential growth, and negative loops that tend to negate any disturbance and to move the system towards an equilibrium point or goal. Combinations of these two kinds of loops appear very frequently and allow system dynamicists to formulate a number of useful theorems or generalizations connecting the structure of a system. The system is represented by a pattern of interconnected interacting feedback loops leading to dynamic behavioral tendencies, ranging from exponential growth to oscillatory or sigmoid patterns.

This simple realization has recently led SD researchers to isolate and describe generic structures, invariably appearing in many management contexts (Warren, 2007; Morecroft, 2007). It should be mentioned here that System Dynamics has even been incorporated in strategic management textbooks by Kim Warren (2007) and John Morecroft (2007). Further the authors (Hadjis and Papageorgiou, 2007), have shown convincingly how the system dynamics approach can be applied in a corporate management model for achieving a rigorous formal testing of a full range of uncertain parameters. These system dynamics models permit the identification of isomorphism in very different systems that can be expected to have similar behavioral patterns. For example, stock and flow will exhibit the same exponential growth pattern in the following situations: a system depicting accumulation of customers through new customers acquired as a fraction of new customers per existing customer; a system of modeling panic, which is filled by an increase in panic multiplied by a growth fraction; a system of a bank balance filled by interest income as multiplied by the interest rate. In all three cases the exponential pattern occurs because the quantity generating the flow (the stock) gets larger as the inflow makes it grow. A larger base for production means a larger flow. A larger flow means a still larger stock. The cycle continues and larger values for the compounding fraction will accelerate the compounding; smaller values will slow it down. This is one of the simple realizations, which have led to the finding of generic structures.

Time delays can be crucial determinants of the dynamic behavior of a system. System dynamics emphasizes the consequences of different lagged relationships in real systems and modelers search carefully for such lags. Further, non-linearities can cause feedback loops to vary in strength, depending on the state of the rest of the system. Linked non-linear feedback loops thus form patterns of shifting loops dominance that generate most of the observable behavior, making their proper identification a necessary prerequisite for the systems dynamicist, for understanding how a system works. A final distinguishing characteristic of the system dynamics paradigm is its emphasis on underlying causal mechanisms whether directly observable or not, and not on observed correlations.

The Market Evolution System Model

The market evolution sector consists of two main chains, one capturing phenomena at the product-market level and one at the company level as shown on Figure 1. A Market is composed of many ideas and relationships. Many of these concepts are obscured in our unreliable intuition about dynamics and although we are confident about their existence, they are ignored in a quantitative analysis process because of the misleading assumption, that we must omit these factors which we are presently unable to measure accurately. In a general purpose corporate model the entire life cycle of a product should be represented and customer levels should reflect the different levels of awareness and readiness to purchase.

In building the model the first focused step was to establish a Reference Behavior Pattern (RBP) which is a plot over time of one or more variables that summarizes the dynamic phenomenon we are interested in studying. At this early stage, a RBP is not a hypothesis in an objectivistic sense whereby the hypothesis should contain clear implications for testing the stated relationship. The RBP documents how a process has been performing in the real system. It is rather a determination of universal elements and an apprehension of relationships. In subsequent iterations and after introduction of additional empirical results by other authors, variables were chosen to be measurable or potentially measurable (by PIMS), thus enabling the testing of model-based hypotheses.

The primary objective is to plot the basic stocks and flow infrastructure for generating the behavior identified. What we seek to identify at first are:

- Conditions and important dynamic states that the sector monitors to determine the state of the system (market and company in this case). These conditions will become levels. Such levels could be different customer groups embracing all subjects who buy the type of product offered by the firm (this equals market volume).
- The activities and processes taking place in response to the conditions monitored by the sector. These will become flows. These could be non-linear functions of the same customer levels of information and awareness levels existing etc.
- The resources consumed in the process. These may be material (bank balances) or immaterial (relative value).

Bearing in mind the above, we propose the following system structure depicted in figure 1 as a stock and flow diagram. The diagram illustrates the concepts of stocks and flows as well as of the feedback loops that help us get an insight to the interdependence of the main elements that determine Market Evolution. Looking at the diagram one can vividly distinguish the main levels of the customer engagement process, which are influence by a number of organizational business environment variables. These variables are derived from important entities of the system such as customer satisfaction quality of the product, marketing effort, average product life, growth rate and so on. The model will be further explained further on this section as it is being evaluated. In the following paragraphs the model of Market Evolution is assessed for its usefulness and validity utilizing the framework of Day (1981), where five questions are examined before a meaningful application of the concept of Product Life Cycle Management can be achieved.

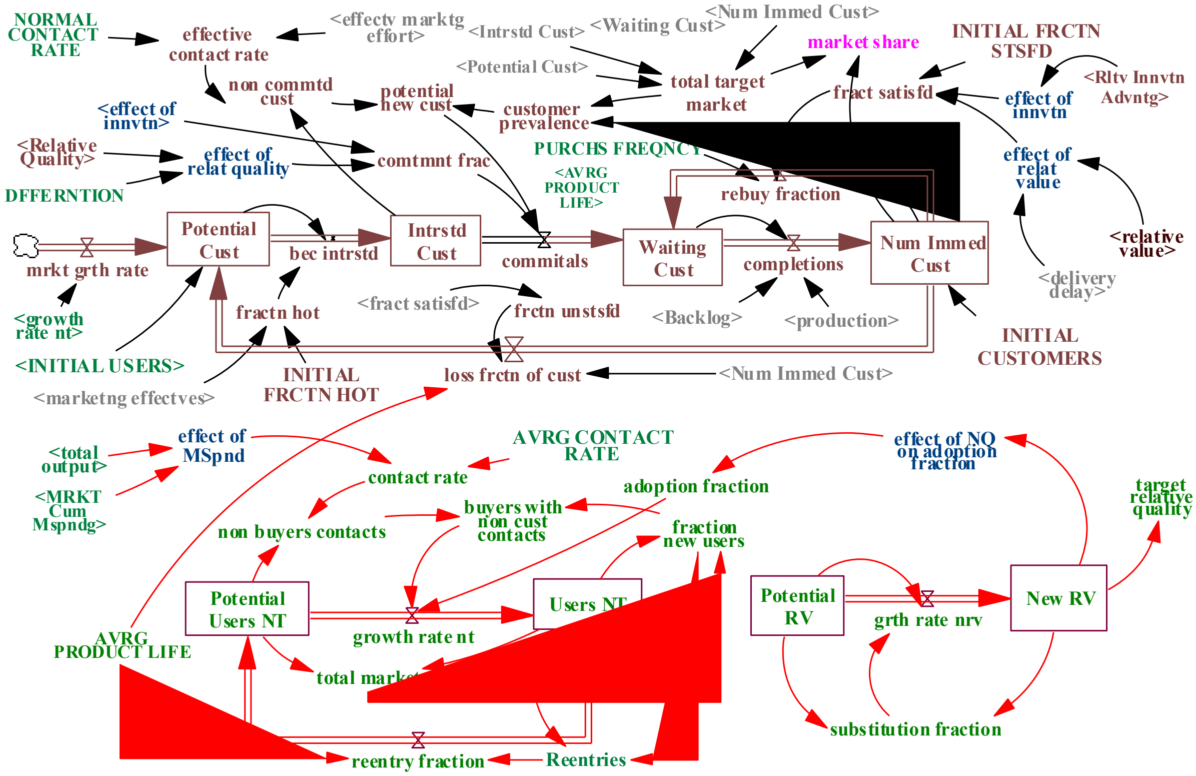

Figure 1: The Market Evolution Model

The problem addressed by the first question involves the decision as to which is the appropriate aggregation level for the purpose of life cycle analysis. The variety of levels of aggregation that characterize hierarchical product structures, extending from the generic product class and industry, to the product form or type and down to variants and brands, presents a major problem to all strategy analysis. The important question is which level captures the consequences of the underlying forces causing change? The complication here is that there are many dimensions along which a product can change. As a result, the question that arises is when does change justify a separate analysis?

Only when there is a significant change along one or more of the product dimensions that involves a sharp departure from the present strategies of the participating competitors is a separate life cycle necessary. The advantage of this “heuristic” is that it can explain long-standing debates that fueled critique on the usefulness of the PLC concept. Examples cited and explained with this heuristic are given below. As an example of a timeless consumer product is Procter and Gamble Tide synthetic laundry detergent and a multiple function material such is the case of Nylon. Note that technological substitution processes such as metal cans for soft drinks changed in terms of material and technology but not function and customers. Moreover, the heuristic of the choice of an appropriate PLC is in perfect agreement with the PIMS definition of served market. That means with the adoption of the heuristic we are in a position to derive measurable, verifiable parameters already existing in the PIMS database.

The second question to answer is which underlying forces influence the sequence and duration of stages in the PLC, as well as the shape of the curve and sales magnitude at each transition to the new stage. In other words, we are interested in the determinants of the rate of diffusion at the initial stage, the factors initiating transition to rapid growth and maturity, and then which factors cause decline. In agreement with research finding at the initial stage the major determinants of the rate of diffusion are: the perceived comparative advantage of the new product relative to the best available alternative, the perceived risk represented by the subjective probability of negative outcome, barriers to adoption such as incompatibility with existing values, commitment to existing facilities, and slow development of supplementary product information and the availability of the product.

The model variables at market level capture exactly the factors identified above, while somehow being PIMS-compatible. For instance the measurable concept of relative value represented by a stock provides a value for the comparative advantage and perceived risk. This combined with total marketing spending are largely determining the rate of substitution of an old product. Adaptation of the product-market structural elements can reproduce all four market evolution stages as defined in PIMS by early growth, maturity growth etc., as well as almost all substitution patterns identified in the past in many product categories. Potential users of the new technology or product shown on the model of Figure 1 as the stock Potential Users (NT) become users through a causal mechanism representing the effects of marketing spending through increases in awareness, expanding in sales, inducing trial, reducing risk etc. The new quality, measurable by PIMS as the variable substitution fraction, which becomes a lookup table in the model, regulates the growth rate of the new relative value, that is, the flow growth rate nrv on the market evolution model of Figure 1. The stock new RV is the new relative value, which gives at any point in time the perceived relative quality as measured by PIMS. This becomes the target relative quality for the company wanting to grow with the market.

Important effects of cumulative industry experience on average industry costs should lead to reduced costs and eventually lowered prices especially in high-tech-industries, which in turn should improve the comparative advantage of the new product for example the prices of mobile telephones. At the individual company level this effect of experience on operating cost fraction represented by operating cost fraction in the model, will only then exert its beneficial effect if company relative price remains at the level of market price represented by parameter market price in the model. Thus this becomes a logical “if then else” statement. Other exogenous factors such as changes in the position of complementary products, changes in government regulations and policies, can also influence the diffusion of the new product. The model thus has to be able to account for them, since they constitute a large part of the management problems to be dealt with, within the sector’s model boundaries.

Transition to rapid growth will be induced by factors, which were latent during the time in which initial uncertainties were being resolved. These will include changes in relationships with substitute products that influence repeat buying. Further, as new features are added and the market expands new opportunities for segmentation and adaptation of product are created to better fit the needs of other niches. This will determine how fast the new product will replace the substitute and how much of the volume will be replaced. Important parameters, which while explaining many of these dynamics also reduce uncertainty or noise sources of the model, are reliably measured by PIMS in different product-markets and their evolutionary stages. Examples are Market Differentiation (see DFFENNTION on the model) defined as the number of purchase criteria and product attributes perceived by the customers, average product life, purchase frequency, average contact rate, effect of differentiation, effect of relative quality loop, industry concentration etc.. For instance, Buzzell (1981) has found that mature markets tend to become less concentrated as the larger firms loose share because they cannot maintain their initial cost advantages. This is revealing competitive turbulence at the maturity stage.

The third question posed above pertains to the identification of boundaries between distinct phases in the variety of possible life cycle patterns. The existence of this variety makes its rather unlikely that the position of a product in its life cycle can be established simply by observing changes in the past sales pattern. Yet, these decisions are of primary importance to planners who are constantly confronted with the problem of the future sales path of the product. Their main concern is to avoid the three planning problems identified elsewhere in the literature pertaining to fail to recognize the life-span and the limits of achievable performance parameters of certain technologies such as the use of ordinary cable vs. fiber optics for transmission of electricity, data etc. The other two problems concern the optimistic extrapolation of the past and the failure to identify maturity and saturation.

The implications of a difference between a temporary (or extended) pause in sales and a true irrevocable trend-change are profound for configuring value potentials. If sensible judgments about the present life cycle are to be reached, obviously forecasting the future sales-path offers the necessary framework. Some of the model-boundary identification problems stem from the sensitivity of this type of analysis towards the choice of measures. Should we use unit volume, current or constant monetary unit or per capita consumption to measure sales? What adjustments should be made to account for the effects of economic conditions? We know for example that certain types of products are especially sensitive to changes in economic activity and this can hide the interpretation of the prospects for the product.

In short we may say that the model structure should be in a position to deal effectively with problems of generating a variety of future product-context-specific future sales-paths, making as sharp as possible the elusive boundaries between distinct stages and removing the distortions caused by the choice of measures. The major concern for all practical management purposes is to avoid the "classical" planning mistakes mentioned above. This we have done by aggregating identifiable variables into a rather invariant "substitution – diffusion" structure, baring also in mind the PIMS-knowledge in the field. The "market level structure" at the lower part of the module attempts exactly that: Market dynamics at the product level are largely determined by contact rate and adoption fraction, themselves being determined by the new relative quality represented by the stock New RQ, which is measurable from PIMS and the effect of marketing spending on contact rate, reliably captured by context-specific information on product-diffusion patterns.

Potential users of the new product or technology according to special interests, are the invariable measures used, as any substitution or diffusion will happen at the level of users. Estimating the number of potential users can be in most of the cases reliably undertaken, while also accounting for the effects of economic activity during the time of interest. With the dissaggregation of this structure and inclusion of more relevant variables, planners can build specific scenarios and hypotheses pertaining to strategic marketing and controlling, innovation management and technology management problems.

The fourth question to examine is the potential for forecasting key parameters of the life cycle, which refers mainly to the suitability and forecasting accuracy of existing diffusion models. Through the years many "first purchase" diffusion models were developed, sharing four characteristics: on the long run, a level of saturation appears; diffusion follows an S-curve; consumers are assumed to be homogenous; marketing decision variables were not explicitly considered.

Improvement to the forecasting accuracy of these models has been mainly sought through the addition of decision variables. However, results were rather disappointing. The attempt of these extensions to make the model as generally applicable as possible has constrained researchers to incorporate only one decision variable at a time. Later research has shown that greater results can be obtained with models including a rich array of marketing variables but applicable only to a narrow set of products. The extension of research on many specific product categories and the enrichment of relevant data in the PIMS database, has made this promising approach possible for our model. In this sense, inclusion of more variables that, as underlying driving force, simultaneously exert their influence on the various accumulations, can drastically increase the accuracy of prjections. Additionally, the absence of successful forecasting models for the maturity and decline stages, a deficiency cited by many researchers, can now be removed. Examples of such variables corresponding to valid PIMS-research findings are effect of innovation, marketing effectiveness, relative quality, relative value, effective marketing effort, all in the upper chain of stocks in the module.

As far as the fifth question is concerned, our intention was to avoid ascribing the concept a single role, that of deriving generalized strategic prescriptions for each stage of the life-cycle, an approach adopted unfortunately by many authors in the past. In view of the recent research findings especially in PIMS projects on market attractiveness, we have taken the stand that life cycle analysis could undertake several roles in the formulation of strategy, particularly in the wider context of substitutions-diffusions, and the interplay between existing-emerging value potentials. In that context, life cycle serves as an enabling condition in the sense that the underlying forces accelerating or inhibiting growth create opportunities and threats having strategic implications, particularly in judging market attractiveness, unfolding segments, forecasting the time and degree of saturation and in general facilitating the smooth transition towards new value potentials, if new potentials are formed at all. In this sense the stage of the life-cycle of a particular product also acts as moderating variable because it reveals for example the value of the present market position and the profitability consequences of strategic decisions. Thus, the model is in a position to generate valid scenarios which could act as conditions to strategy and actions to be adopted in the competitive field.

We must however not forget that the stage of product life cycle is mainly a consequence of strategic decisions. If the learning process of recognizing a new business logic emerging in the business system and developing the core capabilities, required for the new rules of the game is slow and insufficient, then core-processes producing to the new requirements will also be inadequate. The result is that most of the products of an organization will be in an advanced stage of their life. PIMS has a measure for this as sales from new products and features, that has known effects on profitability. We know for example from PIMS that while percentage of new products has a positive effect on market share gain, it has a rather short term negative effect on ROI. This is of course a very generalized statement to be used for taking managerial action. For all practical purposes, management has to know how far market share can be increased without unbearable strains on existing resource configurations and spending, or how much spending in new products and features can be sustained.

Conclusions and Future Work

An organization's ability to continuously adapt to new market conditions is a matter of survival in today's turbulent business environmental conditions. Product Life Cycle concepts and market dynamics need to be properly understood by managers before any plausible strategies are developed for successful product design and launching. The need for an integrated approach for managing the web of interdependencies between people, organizational processes and market characteristics becomes prominent.

This paper reviewed the problem of Product Life Cycle Management in relation to the System Dynamics approach. As a result an integrated model of market evolution was developed depicting the most important organizational and market characteristics based on data provide by PIMS. The model was assessed on a number of questions related to its ability to: define the product-market problem situation; to emulate the evolution of the product through the stages of initiation, growth maturity and decline; to establish the position of the firm's product in relation to its life cycle and the market; to forecast key parameters, such as the magnitude of sales, duration of stage and shape of curve; to provide information via the PLC for formulating effective strategies.

We may conclude that the System Dynamics market evolution integrated model presented in this paper represents a very attractive proposal for Product Life Cycle Management. The proposed model could envisage the organizational and market dynamics via computer simulation experimentation, where the interactions between the interdependent parts of the organization and its business environment, could be observed by managers in the form of explicit knowledge, whereby strategies may be developed and evaluated prior to their implementation in an artificial market evolving environment. The authors plan to could carry out further research to test the robustness of the model by means of using data from a number of world-known case studies of Product Lifecycle Design and implementation.

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