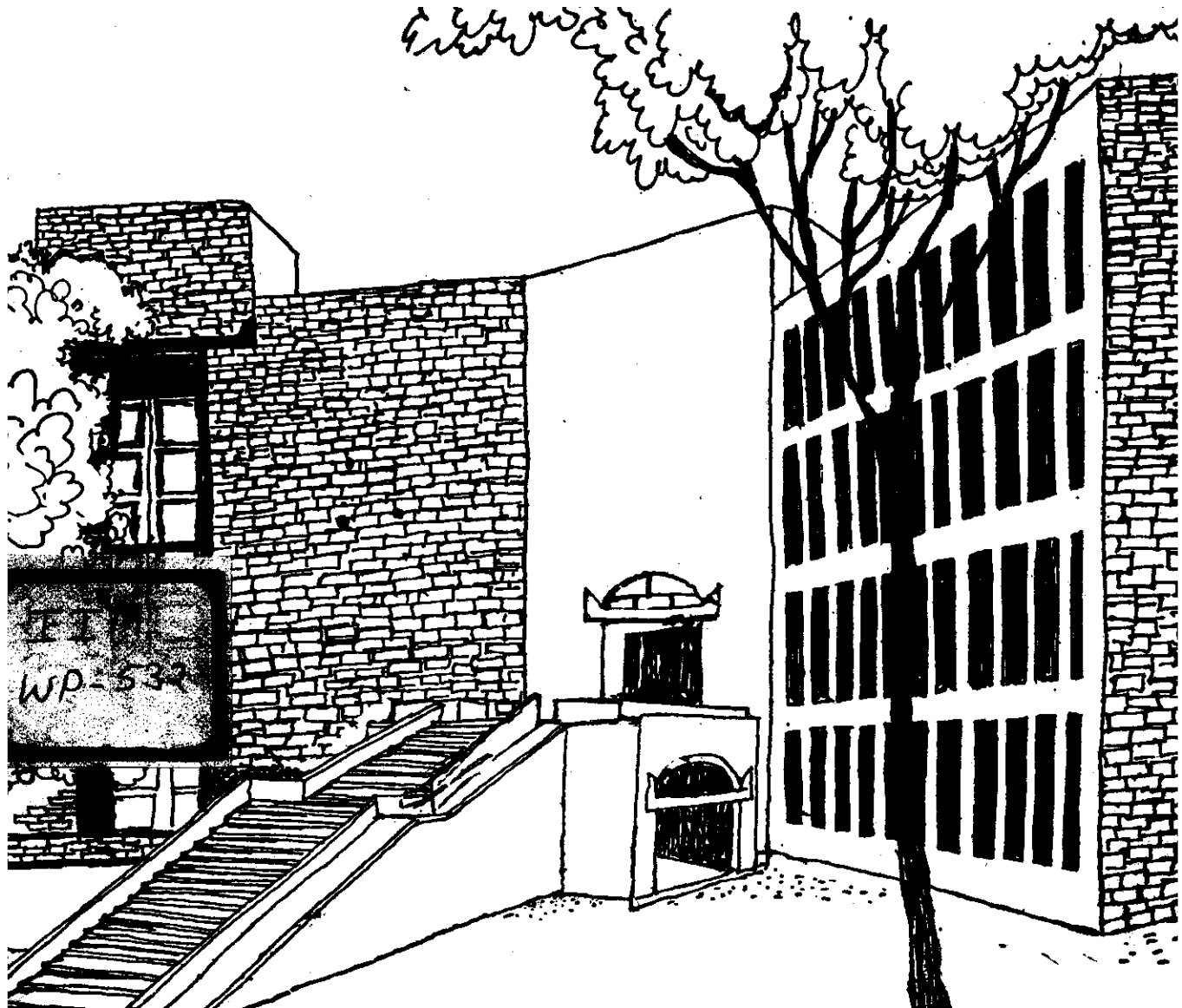




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PLC: STATE-OF-THE-ART REVIEW

by

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ABSTRACT

Two decades of discussion has still to clear the fog surrounding the validity of the PLC concept.

This paper reviews available evidence, and attempts to identify some of the issues that PLC researchers need to address. Literature pertaining to the following dimensions of the PLC concept have been examined:

- a) Empirical investigations
- b) Theoretical investigations
- c) Managerial applications of the PLC concept
- d) PLC in international trade.

Finally, PLC has been evaluated as a theory. The conclusion is that the PLC concept falls substantially short of fulfilling the requirements of a theory. This will be possible only if hypotheses for PLC patterns that are product - specific, market-specific, and time-specific, can be proposed and tested. These will have to include provisions for variations in PLCs, in response to changes in exogenous variables.

A. INTRODUCTION

Two decades of discussion has still to clear the fog surrounding the validity of the PLC concept. Broadly stated, the Product Life Cycle theory supposes that all products pass through a birth-death life cycle much like that of the human being - introduction, growth, maturity, and decline. There is no denying this cycle, but that is not saying much, for all matter in this world whether animated or inanimated, exhibits this sequence. Agreement on the PLC concept stops at this point. Opinions range between extremes with some like Mc Carthy (14) referring to it as a plain, proven fact of life, some like Doyle (7) calling it only "a concept", and still others like Dhalla and Yuspeh (6) calling it a "mere notion".

B. EMPIRICAL INVESTIGATIONS

Empirical efforts have led to mixed results. While the sequence of birth-death life-cycle is undeniable, problems are confronted the moment one proposes a specific shape or time - scale for the PLC. Rink and Swan (18) have attempted a comprehensive literature review

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of nineteen published efforts to show actual life cycles. The study indicates that a number of shapes other than the classical bell-shaped prevail, and at least twelve different shapes have been revealed. Further, in the existing empirical work there is a bias toward consumer rather than industrial products. There is also a difficulty of comparison because of different levels of aggregation, namely product class, product form and brand.

Polli and Cook (17) state that "the expected time-pattern for the stages, while extremely important, is often dismissed with the thought that it depends on the product in question". They also point out that the general concept of PLC as examined in literature is taking only demand-factors into consideration, since the theoretical base of PLC is on demand-considerations. The reality of market - conditions requires that 'supply-side' too be taken into consideration. Their study shows that the PLC model shows its best performance where demand factors are dominant.

Attempts to develop a taxonomy of product life-cycles across product classes have been very few, and across market-characteristics, none. Harrell and Taylor (10) have attempted to model a PLC for consumer durables using data of the housewares industry. Their model is a mathematical expression, wherein any point on the PLC constitutes of two components: (i) Original purchases, and (ii) Replacements. These variables are estimated through a simulation model which provides for causal factors like aggressiveness of the marketplace as shown by consumer need, number of competitors, amount of advertising and promotion in the market, and price-erosion rates. The model does not however provide for differences across markets, and for exogenous influences on the PLC such as economic cycles, supply constraints, labour disputes and material shortages.

Thorelli and Burnett (22) have examined the nature of PLCs for industrial goods businesses, in a study funded by the Strategic Planning Institute, USA. This study examined the market structures, performance, and strategies of over 1000 industrial businesses to determine whether and to what extent PLC forces were at work. The findings indicated that the growth rates of

industrial product-markets are but one aspect of the PLC. Other variables exhibiting life-cycle behaviour included market innovation, market concentration, competitive entry, and spending on R&D and marketing. The paper however, does not provide or develop any generalization for a taxonomical basis for a PLC of this product-type.

In general, the following broad issues appear to prevail in most empirical work.

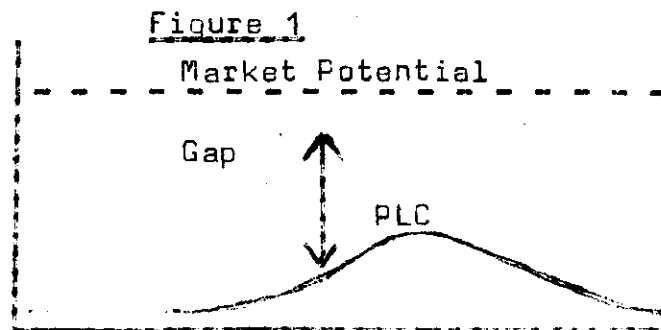
- i) Level of product aggregation: This is the issue of whether the PLC should be plotted at the generic level, product-form level or brand-level. Most practitioners seem to agree that it depends on what information is sought. The PLC should be defined at a level which captures the underlying dynamics, such that it is relevant to the context of the immediate decision-making.
- ii) Level of market aggregation: A related question is that of the geographic level, and level of market-segment at which PLC should be plotted. This problem has received even less attention than the issue of level of product aggregation. The answer to this question would be that the PLC should be plotted at that level

at which the strategy is being formulated. It would depend on the level of disaggregation at which unique or differentiable action is possible. Forexample, every single customer is different and unique in his own way, but differentiable action is not possible at that level.

iii) Unit of measurement: A third problem most empiricists face is that of the unit of measurement. Some prefer to use dollar value, while others use volume of sale in units. This can make comparisons difficult.

iv) Saturation level: The total available market potential is an important factor in determining the amount of sales available for a product. It would be meaningless to talk of the sales performance of a product without considering its level of saturation in relation to the total market potential. This factor has been mostly ignored by empirical researchers. It should be especially noted that the reference here is not to the relative market-share of any particular brand. The reference here is to a low penetration rate of the entire product-class in relation to the total possible market, a situation very typical in less-developed nations.

The figure below typifies a PLC of this nature -



As indicated, there is a gap between the total potential available and the shape of the penetration curve (PLC curve).

Some of the more recent works, attempting to borrow from diffusion theory and build quantitative models of the PLC, have taken this factor into consideration (Harrell & Taylor (10); Tigert & Fariver (23)).

According to George S. Day (5), the following five issues must be raised and answered in any empirical investigation of the PLC:

- i) How should product-market be defined for the purpose of life-cycle analysis?
- ii) What are the factors that determine the progress of the product through the stages of the life-cycle?
- iii) Can the present life-cycle position of the product be unambiguously established?

- iv) What is the potential in terms of methodologies available, for forecasting the key parameters including the magnitude of sales, duration of the stages, and shape of the curve?
- v) What role should PLC play in the formulation of competitive strategy?

C. THEORETICAL INVESTIGATIONS

Attempts at validating PLC as a theory have been very few. Two recent efforts worth mentioning are those of David Midgley (15), and Tellis & Crawford (21). Midgley in an exceptionally strong paper in a theoretical sense, has attempted to explain the variability in patterns of PLC curves as a function of the ratio of mean adoption to mean interpurchase time, and depth of repeat. Using these dimensions, he has constructed a simulation model to generate the sales consequences of certain assumptions about consumer behaviour, and thereby illustrate the various PLC patterns that are theoretically possible. His is probably the only genuine effort in attempting to explain PLC patterns using not sales as the independent variable, but other more fundamental variables. Tellis and Crawford offer an alternative explanation for the PLC. Drawing from the biological analogy, they state that the dynamics of a

product's existence is closer to that of the "evolutionary cycle" than the "birth-growth-death cycle". The birth-death cycle applies only to specific individuals, whereas the evolutionary cycle applies to entire species. The alternative model, the Product Evolutionary Cycle (PEC) that they offer, certainly seems to have better explanatory power than the PLC. Unlike the PLC which is a self-limiting activity, the PEC is determined by managerial and entrepreneurial creativity, the market consisting of consumers and competitors, and government and other agencies. The analogy in biology is that of the generative force, the selective force, and the mediative force. The PLC is deterministic, whereas the PEC is dynamic, that is, any stage can follow or precede any other. This appears to be closer to reality.

Surprisingly, not much has been drawn from diffusion theory, the other major theoretical base of the PLC curve. The S-curve diffusion model which was first used by Rogers (19) to explain diffusion of innovations, has a shape very similar to that of the PLC curve. This curve, particularly using a lognormal or logistic equation, has been able to provide a good fit to new product diffusion data (Bain (2); Griliches (9); Mansfield(13)).

If similar attempts can be made to model the product life-cycle atleast with respect to some product and consumer categories, it will mean an advancement in the predictive power of the PLC. The potential of the growth model for new consumer-durable products, proposed by Bass (3), is also largely unexplored. This is strange considering that his model is shown to have very good predictive ability. Bass applied his model to the sales time series of eleven major appliance innovations, including room air conditioners, electric refrigerators, home freezers, black & white televisions, power lawn mowers, and so forth. The equation was estimated by least squares regression from the following expression:

$$Q_t = p\bar{Q} + (r-p) Q_T - \frac{r}{\bar{Q}} Q_T^2,$$

where,

Q_t = number of adopters in the current period

Q_T = cumulative number of adopters to date

\bar{Q} = total number of potential adopters

p = coefficient of innovation

r = coefficient of imitation.

The predicted sales matched the pattern of actual sales quite well, with the coefficient of determination $R^2 = 0.92$. However, when Tigert and Farivar (23) tried to use the Bass model to predict the sales of optimal scanning equipment, a high-technology product, it produced a poor fit.

Most diffusion models have been formulated in the context of diffusion of innovations, or transfer of knowledge. Diffusion of an innovation has been regarded as a "technological substitution model" (Olshavsky (16)). This raises a related question as to whether PLC behaviour is truer of technology and embodied knowledge. Polli and Cook (17) state that saturation is reached only if new product forms are not feasible with existing technology, and if new uses cannot be found for existing forms. The maturity stage for a general product class can be interpreted as saturated only by taking as given, the state of technology and applications for existing product forms within the product class. George Field (8) questions the validity of the PLC for consumer and high-fashion products. There are innumerable instances, he says, of once supposedly obsolete products coming back to life, especially in highly consumer-involving items such as fashion, furniture, and music. This argument stimulates one into thinking that what really becomes obsolete is probably not the product, but its utility. Therefore, it appears that the PLC is likely to have greater validity in the case of technology and products with a knowledge-base, for utility in such cases is clearly-defined

reality and not a subjective perception of the consumer. This perspective needs to be explored further and empirically investigated, before accepting it as fact.

D. MANAGERIAL APPLICATIONS OF THE PLC CONCEPT

One approach would be not to get bogged down with the issue of the validity of PLC as a theory, and merely to look upon it as a guideline for managerial action. This would be a purely normative approach. Catry (4) has suggested a scheme of market-share strategy linked to the stage in product life-cycle, and the position of the firm in the market. During the introduction stage of the product life-cycle for example, all firms irrespective of their size might want to follow a Market-Share Building Strategy. During late maturity stage, a Market-Share Maintenance Strategy is suggested for small firms, and Market-Share Reduction Strategy for large firms. Various such combinations have been considered, and appropriate Market-Share Strategies suggested. Levitt (12) suggests that if the PLC concept has to have any implications, then the stage of the life-cycle should be recognized and attempts made to forecast the sales. He also suggests advance planning for "stretching" the life-cycle, by appropriate rejuvenating techniques when

required such as

- i) promoting more frequent usage of the product among current users.
- ii) developing a more varied usage of the product among current users.
- iii) creating new users for the product by expanding the market.
- iv) finding new uses for the basic material.

John Smallwood (20) takes the most extremist of stances among those with a normative approach, by suggesting that the PLC concept is a key to strategic marketing planning. He further proposes an elaborate grid giving details of various strategic actions that would (or should?) follow in each of the stages of the product life-cycle.

The major fallacy in adopting a purely normative approach is that it could well lead to a self-fulfilling prophecy. To suggest action without being able to offer an explanation for the event is like being reactive, not proactive. Prediction without an understanding of the underlying events is unlikely to be accurate, and may call for too many exceptions. Being "theoretical" therefore, is not being out of "reality", but furthering "reality".

Given the existent state of empirical evidence, it would be safe to adopt a moderate stance with

regard to normative prescriptions based on the PLC concept. This feeling is best echoed by George S. Day (5) when he states that one should not make generalized strategic principles based on the PLC concept. It should be considered as a moderating variable which is one of the elements in the total scenario, that has implications for strategic marketing. It is not a *fait accompli* which can only be reacted to, and instead should be interpreted in the context of several other inputs in the actual situation.

PLC IN INTERNATIONAL TRADE

It would not be out of place here, to consider the role of PLC in international trade as well. The comparative cost doctrine has been found to have limitations in explaining actual international trade behaviour, one instance though not the only one, being the "Leontief Paradox" (24). The paradox shown by Leontief was that the ratio of capital to labour in U.S. exports was lower, not higher than its production when imports displaced it (this is contradictory to the comparative cost doctrine). Vernon (24) states that equal access to knowledge of a scientific principle is not the same thing as embodiment of that principle in a marketable product. This embodiment is

governed by local demands and conditions. In USA for example, average income is high, and therefore there would be a greater demand for capital-intensive, labour-saving devices. Economic theory would suggest that existence of demand does not mean the production unit should be located at the same spot. Location is governed only by least-cost considerations, of factors of production and transportation. However, the proposition made by Vernon is, that in reality location is not governed by such simplistic principles. Other major factors affecting location are problems of communication and external economies as follows:

- i) The product is unstandardised in the early stages. Therefore, the producer requires greater freedom in changing inputs and a general flexibility during this phase.
- ii) Because of unstandardisation and product differentiation in the early stages, price elasticity is comparatively low.
- iii) There is a need for swift and effective communication on the part of the producer with customers, suppliers, and even competitors in the early stages.

All these conditions, more often than not, lead to the production unit being located near where the demand is, than elsewhere. This initial stage

of the unstandardised product is followed by that of the maturing product. During the second phase, the need for flexibility declines which makes economies of scale possible. As product characteristics are now improvised to the optimal level, production cost acquires priority. Local manufacturers in the foreign countries see a missed opportunity, and so they step in. The final phase is that of the standardised product, when the requirement for flexibility becomes redundant. During this phase the product is highly price-elastic. Need for sophisticated communication with other channel members is no more a constraint. During this phase the foreign investors go into the less developed nations, and finally because of the economies of scale attained, begin exporting to the US itself. The phenomenon discussed by Vernon seems to account for the Leontief paradox as well. In the initial stages when the product is still unstandardised, the volume of output and degree of certainty is not high enough to facilitate investment in relatively inflexible, capital-intensive facilities. At this time therefore, though US is exporting, labour input is heavy. By the time the product is standardised foreign competition has entered the fray, and therefore contrary to the realms of

the comparative cost doctrine, when labour cost is low US ends up importing the product.

This economic behaviour has been crystallised further in terms of its implications for international marketers, by Louis T. Wells (25). He has identified four stages of the life-cycle model as follows:

Phase I: A profitable segment abroad is identified by home manufacturers. Since proximity to the other channel members and flexibility is more important than cost differences due to freight and other factors in the early phase, location of manufacturer is generally within the home country. Therefore, US export begins and grows in the market.

Phase II: As incomes and product familiarity abroad increase, the market becomes large enough to attract foreign producers located close to the market. Many of the costs of the foreign manufacturers are less than for US manufacturers due to lower labour and freight costs. Yet the American manufacturer continues to have some advantage due to economies of scale. During this period there is a slowdown in the rate of growth of US exports of the product.

Phase III: Foreign production grows and becomes

competitive in third countries. They benefit from economies of scale and become increasingly competitive.

Phase IV: Import competition begins. The costs of the foreign manufacturers become so economical, that they are able to pay import duties and compete even in the US home market. This cycle becomes true one by one for all countries in descending order of their state of development/income, that is, each country's export market is taken over by some other less-developed nation.

There are three critical variables affecting the pattern of the trade life-cycle.

i) Domestic base: Exports are likely to be higher for those products for which there is a wide domestic base, and in the manufacture of which domestic producers are themselves strong. In USA for example, it is true of high-income luxury items. It is also true of labour-saving capital-intensive devices.

ii) Economies of scale: Substantial exports and a predictable pattern of trade cycle are possible only if economies of scale are available through increased production. If economies of scale are low, and even a small plant can be as efficient as a large plant, then there will be quicker and greater foreign competition.

iii) Costs of tariffs and freight: The freight costs and tariff costs affect the predictability of the trade life-cycle. If these are high then it becomes easier for foreign producers to compete in their own markets.

Wells (26) empirically examined the criticality of these three variables in determining the pattern of the trade life-cycle, and found them to be crucial determinants, as hypothesized. US exports-growth was closely linked to products with high income-elasticities, high economies of scale, and low transportation costs.

The major criticism that can be levelled against existing empirical evidence for the international product life-cycle is that it has been examined almost entirely from the angle of USA. A fuller acceptance of this theory would require empirical substantiation from the standpoint of other less-developed nations as well. The only one attempt in this direction by Igal Ayal (1) unfortunately suffers from theoretical weaknesses. He has ignored the three critical conditions affecting the pattern of the trade life-cycle, viz. prior domestic base, economies of scale, and tariff and freight costs, and

straightaway proceeded to make the hypothesis that: "Success of Israeli exports is an increasing, then decreasing function of phase in the US International Product Life Cycle. Best results will be attained in the third phase (middle phase) of the US Cycle." He has then compared the export performance of Israel in 65 industries (as many as for which data were available) with the stage of each of these industries in the US trade life-cycle. Naturally, his study did not lead to any meaningful results, and in fact turned out to be opposite to that predicted by inter-national life-cycle theory. A meaningful comparison would require that the status of the product-class in terms of the critical variables discussed, be determined. Since the US international trade life-cycle has been used by the author as the base for comparison, his hypothesis would be valid only for those products which have a prior domestic base in USA (such as highly income-elastic products), manifest high economies of scale and low transportation costs. Two other major weaknesses in his study are -

- i) Israel is not a typical less-developed nation, as its interests are very closely linked with that of USA.

- ii) His analysis is only a single-country analysis. For conclusive results, data of more number of countries need to be examined.

F. EVALUATION OF PLC AS A THEORY.

The paradigm being used here to evaluate PLC as a theory is as proposed by Shelby Hunt (11). Existing PLC explanation is merely an analytic explanation and a tautology; for on the one hand level of sales is used to determine the stage in life-cycle, and on the other, stage in life-cycle is used to predict future sales and suggest appropriate managerial action. Unless and until the product life-cycle can be refined to the point where the stages can be identified independent of the sales variable, the life-cycle concept will remain impotent and void of explanatory power.

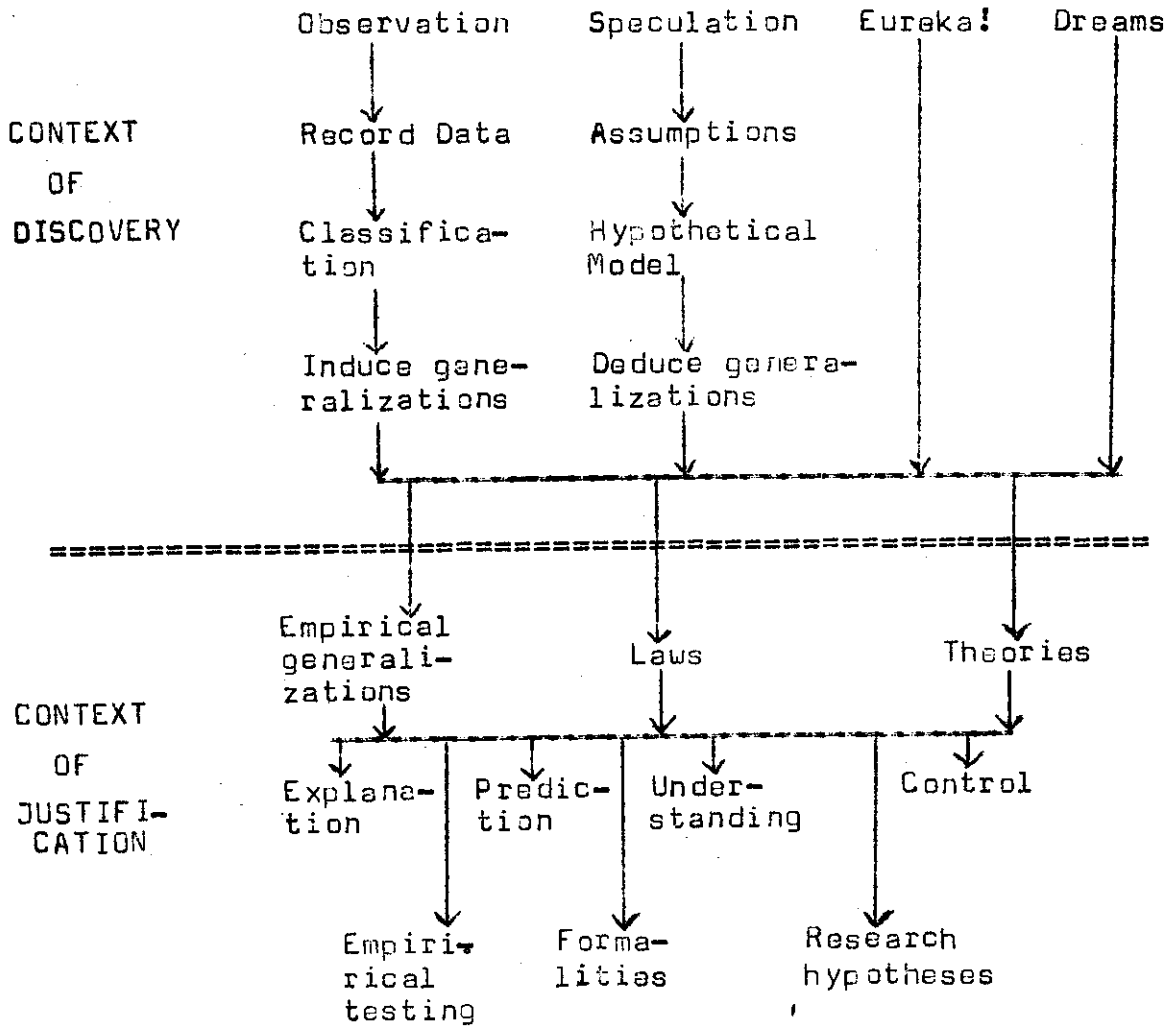
Hunt cites the most serious shortcoming in evaluation of theory, as that of the confusion between the "context of discovery" and the "context of justification". Discovery is only the beginning, a take-off for empirical justification. It is only when the discovery has been validated in the "context of justification" that it becomes a theory. There are ways and means of discovering,

the set of such systematic rules and procedures constituting the "context of discovery". Similarly, the set of systematic rules and procedures which enable validation or rejection of the discovery, constitute the "context of justification". Figure (2) illustrates in detail the processes involved in the "context of discovery" and the "context of justification".

Discovering something requires no theoretical rigour. It could be through dreams, or simply accidental as was the case with Archimedes. Alternatively, it could be through an inductive process, that is, through the process of observation, recording, classifying and making induced generalizations. Or it could be through a deductive process, as indicated through the second route.

Many of marketing discoveries are through the inductive approach. The typical marketing research problem exemplifies this. But this is only discovery, not theory. The PLC concept is no exception. All that has been done is that observed data has been recorded, classified, and generalisations made. These induced generalisations are only in the 'context of discovery'. Making law-like or empirical generalisations and constituting

Figure 2
DISCOVERY VERSUS JUSTIFICATION



Source: Hunt, Shelby D. ; MARKETING THEORY: CONCEPTUAL FOUNDATIONS OF RESEARCH IN MARKETING; (Columbus, Ohio, Grid Inc., 1976)

a valid theory involves much more, as we shall shortly examine. This would be largely in the domain of the 'context of justification'.

A theory is defined by Richard Rudner (11) as "a systematically related set of statements, including some law-like generalisations, that is empirically testable. The purpose of theory is to increase scientific understanding through a systematized structure capable of both explaining and predicting phenomena". Lawlike generalisations are statements that specify a basic relationship of one of the following two forms, (i) "All A are B" or (ii) "If X occurs then Y occurs", and that (a) have empirical content, (b) exhibit nomic necessity, and (c) are systematically integrated into a body of scientific knowledge. Laws are such lawlike generalisations that have substantial corroborative empirical support.

Theories must contain lawlike generalisations because it is precisely these statements that give theories their explanatory and predictive power. Theories must be empirically testable in order that they may be, (a) intersubjectively certifiable, (b) capable of explaining and

predicting real-world phenomena, and (c) differentiated from purely analytical schemata. A theory is capable of being empirically testable when it is possible to derive from the theory certain predictive-type statements (hypotheses) that are amenable to direct confrontation with real-world data.

It is obvious that the PLC concept falls substantially short of fulfilling the requirements of a theory. Existing PLC literature provides no evidence of lawlike generalisations. Even the basic relationships of the nature 'All A are B' and 'If X occurs Y occurs', have not been crystallised so far. Such hypotheses can be formulated for PLC only if product-specific, market-specific and time-specific relationships can be proposed. None in existing literature belong to this genre. Proposition of such relationships would be largely in the 'context of discovery'. Thus, leave alone scraping for empirical generalisations, even the logic of discovery for PLC is not complete; this will be complete only when induced generalisations **stating** basic relationships in a manner suitable for empirical testing are formulated. Such relationships can be possibly stated only if the

underlying factors affecting the PLC curve can be comprehended; a reinforcement of the requirement of understanding and explanation for prediction. These would have to be in the nature of patterns of PLCs specific to product typologies, consumer typologies, and passage of time. Variations in PLCs in response to changes in exogenous variables would have to be provided for. Empirical testing and validation would follow from this. If future attempts in PLC research are guided along this direction, we would have taken one step closer to not merely increasing the "rigour" of PLC as a theory, but to endorsing that Marketing itself can be a theory.

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