Analytic Support for Managing New Industrial Products

Jean-Marie Choffray*
and
Gary L. Lilien**

CERESSEC DR. N° 84003 January 1984 (revised)

* Professor of Marketing and Management Science, ESSEC Cergy-Pontoise 95021 France.

** Research Professor of Management Science, The Pennsylvania State University.

ABSTRACT

New products are substantial sources of growth in industrial markets. They are also risky. In this paper, we review some analytical tools to aid in the design of new industrial products and in the management of new product sales growth. The approach developed here contrasts with the "traditional" qualitative approach to industrial marketing research, blending product design optimization with diffusion analysis to investigate a new product's market potential and to plan marketing strategy during the introduction and growth stages of its life cycle. Several application examples illustrate how these new tools have helped support industrial product design and market development decisions.

1. BACKGROUND

New industrial product development and introduction has been characterized as "creeping commitment," where large sums are invested bit by bit in the new product venture with little market analysis. This type of management is risky in view of the shortening of the expected life of new industrial products and technologies and their high failure rate (Choffray and Lilien, 1980).

New products are a substantial source of growth in industrial markets and their importance is growing. Many American firms generate sixty to eighty percent of their sales from products that were not in existence ten years ago (Office of Economic and Cultural Development, 1977). Hopkins (1979) reports that over twenty-five percent of industrial firms have more than thirty percent of their current sales attributable to major new products first marketed within the preceding five years. Thus, the development and successful introduction of new products has become a major strategic objective for most firms. Piatier (1981) in a survey of the European industry reports that the majority of industrial companies have this as their primary objective.

New industrial products are not a panacea, however. There are risks. Mansfield and Wagner (1975) report an average twenty-seven percent rate of commercial success for industrial product development projects. Booz, Allen and Hamilton (1971) report similar results across industries. On aggregate, more than seventy percent of all money spent on new industrial product activities is spent on products that are never commercial successes.

The development, introduction and marketing of new industrial products require large financial outlays, often in the multimillion dollar range. Product design is by far the most important development cost component accounting for about 70 percent of these costs. Market introduction, however, is more costly, accounting for more than sixty percent of the total development and introduction investment (Urban and Hauser, 1980). This cost structure does not vary substantially across industries (Mansfield and Rapoport, 1975).

These high costs and high failure rates suggest the need for careful engineering and market potential studies during the design stage of the new product development process and the need to plan and monitor new product growth during the introduction phase. A study of the industrial innovation process in France suggests that good market analysis is not standard practice. About forty percent of those firms that performed such analysis consider that the evaluation proved unreliable (Lafeuille, 1981).

In this paper we review analytical tools to help firms (1) assess market potential prior to final industrial product design and (2) forecast sales growth and plan marketing strategy during introduction. The approach blends product design methods with diffusion analysis. Several examples illustrate how these tools help industrial marketers in several countries make product design and market development decisions.

2. ASSESSING INDUSTRIAL MARKET RESPONSE: CONCEPTUAL FRAMEWORK

We define the target market as the demand of those organizations that an industrial firm selects as the target for its new product. This is the result of a strategic decision reflecting the basic mission of the firm.

The potential market is the demand of that subset of the target market that considers the new product as a possible alternative. The potential market includes all those firms that find the new product's design acceptable. Different designs -- or sets of products' physical characteristics -- lead to different market potentials.

The projected market is the time growth of sales as a function of marketing decisions and the related adoption/diffusion process. Exhibit 1 illustrates these different definitions. We are concerned here with the assessment of the two last levels -- potential market and projected market -- for new industrial products.

The assessment of the potential market and the projected level of demand for a new industrial product requires that the nature of organizational buying be considered. This behavior is characterized by

- the involvement of several individuals with different backgrounds and responsiblities,
- who interact with each other within a decision marketing structure, and
- whose possible choices are constrained by organizational needs and requirements

Hence, an operational model of industrial market response should handle organizational heterogeneity at these three levels:

- Customer organizations differ in their need specification dimensions, that is in the criteria they use to define their purchase

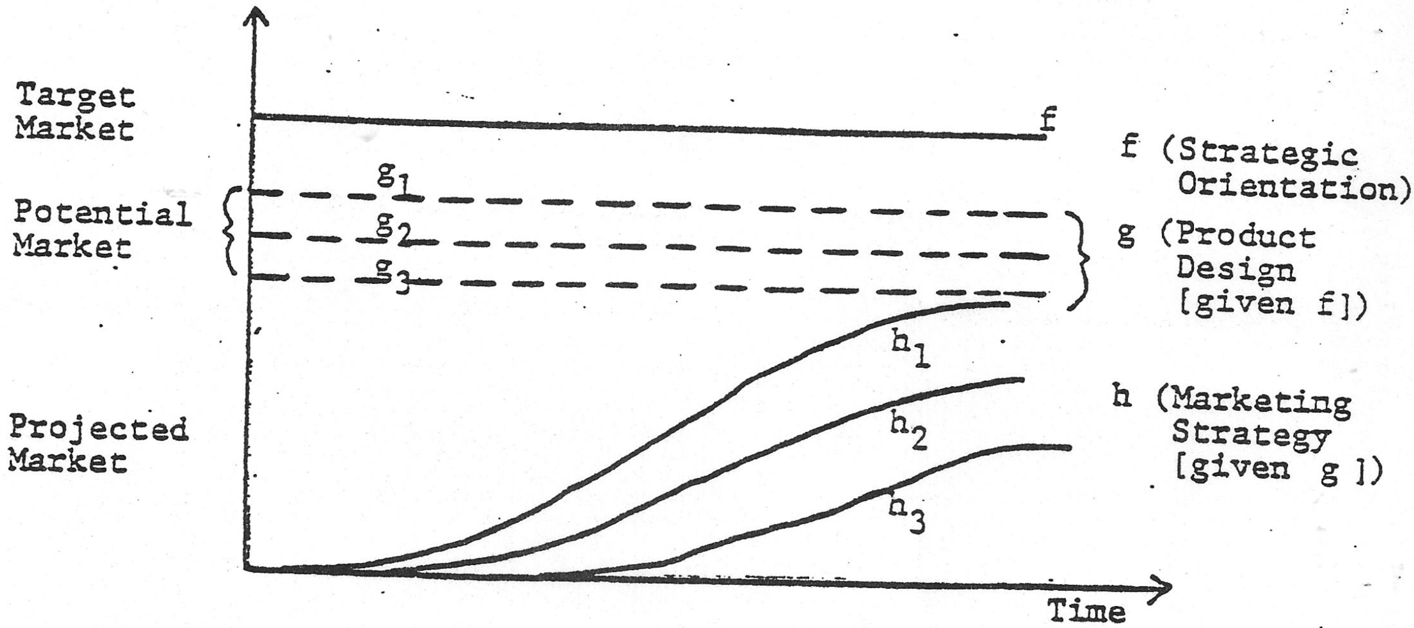


Exhibit 1: Three market definitions for a new industrial product

requirements (payback, ROI, etc.). They may also differ in their requirements along a common set of such dimensions (4-year paybacks vs. 3-year paybacks).

- Target customer organizations differ in the composition of their buying centers -- in the number of individuals involved, in their specific responsibilities and in the way they interact.

- Decision participants involved in the buying center differ in their sources of information as well as in the way they evaluate products.

The consideration of these sources of organizational heterogeneity requires tools to support new industrial products decisions that differ from those commonly in use for frequently purchased consumer goods (Urban and Hauser, 1980; Wind, 1982).

Choffray and Lilien (1980) developed a general methodology that assesses likely market response to industrial product offerings, beginning with market definition, segmentation analysis, product awareness, product analysis feasibility or acceptability, individual and group selection and the analysis of product growth. In the sections that follow, we develop the feasibility decision model and the growth model more fully.

3. ANALYTICAL TOOLS

In the subsection below we develop product design optimization procedures that lead to assessment of market potential assessment within a pre-selected target. In the next subsection, we discuss normative growth models that can provide a time path of forecast demand for the product.

3.1 Assessing Market Potential for a New Industrial Product

New industrial product adoption may be viewed as a sequential elimination process (Webster and Wind, 1972; Choffray and Lilien, 1980). Within a target firm, new product features are matched against purchase specifications, to screen out alternatives that do not meet requirements (Crow, Olshavsky and Summers, 1980). The number of firms that find all characteristics of the new product acceptable provides a measure of market potential.

Several approaches have been used to relate the design features of a new industrial product to its market potential, two of which are reviewed below.

3.1.1 Conjoint Measurement. The conjoint method estimates a set of utilities for the individual product attributes that, given some composition rule (most often simply adding the utilities), are consistent with the respondent's evaluations. (Green and Wind, 1973; Green and Srinivasan, 1978).

Use of this approach for industrial product design and to assess market potential proceeds as follows:

> Measurement: Decision influencers within target microsegments are presented product profiles whose characteristics are varied according to a factorial or fractional factorial experiemental design. This assumes that all relevant dimensions be identified in advance and that discrete levels -- corresponding to specific, technologically feasible product designs -- be defined. Respondents are then asked to rank-order the profiles.

Calibration: A number of analytical methods can be used to provide a set of partial utilities for each design characteristic. These partial utilities are combined -- usually by addition -- to provide an overall utility for a product design.

Market Potential Assessment: To relate product features to market potential, overall utilities are converted into acceptance probabilities and aggregated. Any one of a class of constant utility models or random utility models (Choffray and Lilien, 1980) can be used here.

3.1.2 Disjoint Measurement. Choffray and Lilien (1982) introduced the use of disjoint measurement as an alternative for new industrial product market potential assessment and design optimization. This new procedure, part of a decision support system called DESIGNOR, more closely parallels the conjunctive nature of organizational acceptance. It is more flexible than conjoint analysis, handling any number or type of purchase specification dimensions, and not restricted to discrete levels of those dimensions.

Measurement: Within a microsegment decision participants are asked to specify along each relevant specification dimension, the minimum, the maximum, or the set of values (interval) beyond which this organization would reject the product independently of any other consideration. Three types of need specification dimension are generally used:

- Boundary Specification Dimensions. In this case the firm specifies an extreme (minimum or maximum value) beyond which a product is rejected as infeasible. A target customer for a lathe may require the warranty period to be at least 18 months and the initial cost to be less than $15,000.

- Range Specification Dimensions. In this case products must fall in a specific range along the dimension considered. Production tolerance ranges are of this nature when the product purchased is to be incorporated in another product or process.

- Discrete Specification Dimensions. Here, for a product to be feasible, it must incorporate specific features (e.g., automatic feed on an office copier).

Calibration: Assessment of the market potential function requires the development of an acceptance model within each target microsegment and its calibration.

A multiplicative model is frequently used to represent the conjunctive elimination process outlined earlier. That model -- the weighted product of the partial (individual dimension) acceptance rates -- permits parameter estimation using weighted least squares. This process is done on a segment-by-segment basis and the results are then aggregated to form a market acceptance function.

Market Potential Assessment. For each possible design of the new product, the DESIGNOR methodology assesses market potential. The multiplicative nature of the model allows for the analysis of nonlinear tradeoffs in product characteristics. Design thresholds can be identified and the model provides an operational measure of the substitution rates among product features. This information, combined with internal cost data, allows for the optimization of the new product given the marketer's penetration target. Exhibit 2 depicts sample tradeoff curves between expected economic life and warranty period for a new industrial solar cooling system. (See Choffray and Lilien, 1982, for methodological details).

3.1.3 Comparison. In choosing between the conjoint and the disjoint approaches, if (a) the number of purchase specification dimensions is reasonably small, (b) linear tradeoffs can be assumed and (c) the purchasing decision process involves only one key individual, the conjoint approach is a good choice. In many situations, the heterogeneity of specification dimensions and the associated requirements make it impossible to specify possible new product profiles a priori. Also, the disjunctive nature of the product acceptance process may preclude the use of a simple linear, compensatory market potential function. For those cases, the DESIGNOR methodology provides a reasonable alternative.

3.2 Forecasting and Monitoring Growth in the Effective Demand for a New Industrial Product

Few new industrial products immediately capture their entire market potential. Usually, the penetration rate, over a period of time, tends to take the form of an S-shaped curve as depicted in Exhibit 1. This process -- substitution -- is characterized by a

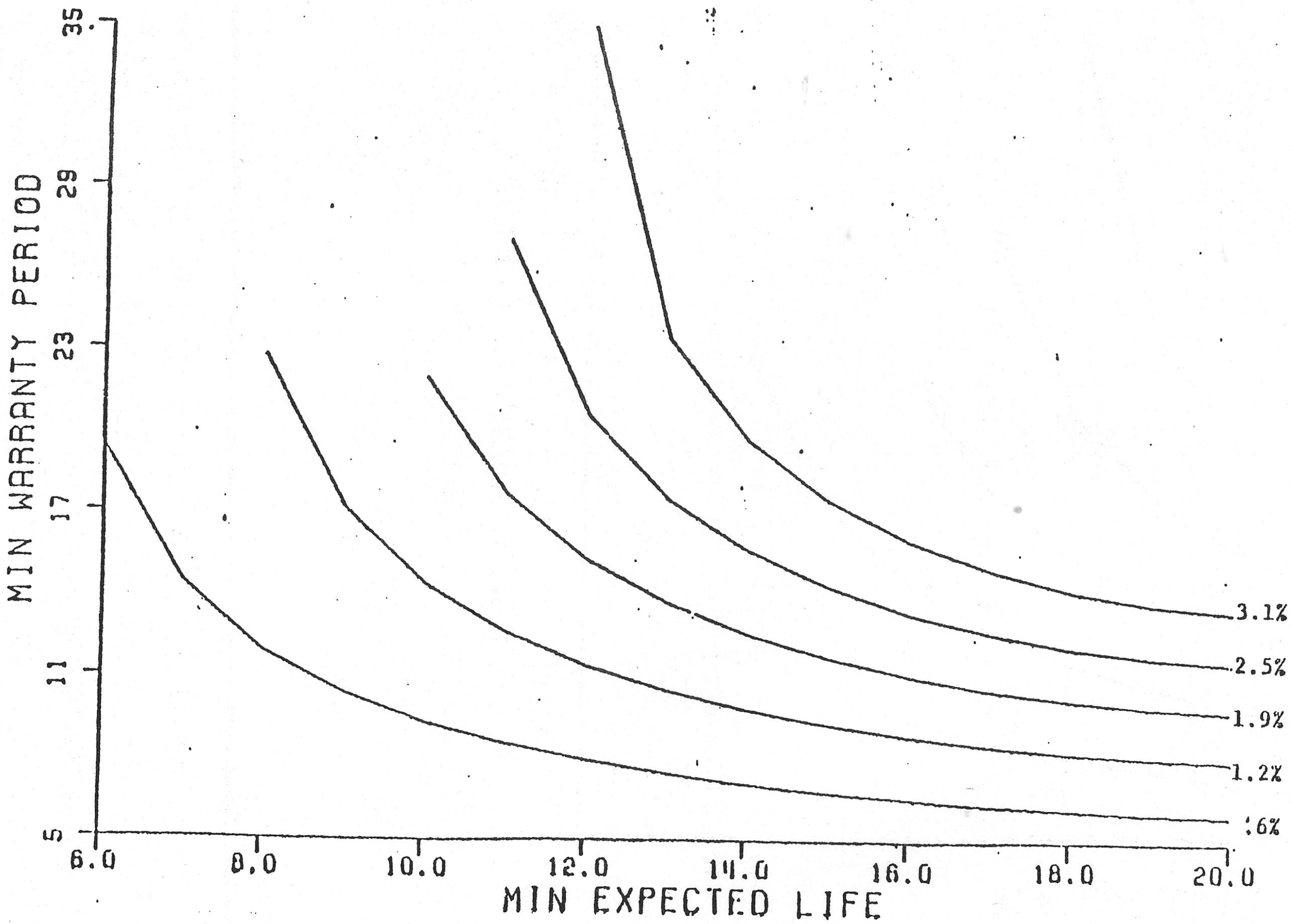


Exhibit 2. Sample tradeoff between expected economic life and warranty period in the case of a new solar cooling system

slow initial rise, followed by a period of more rapid growth, finally tapering off to a saturation value, corresponding to the potential market of the new product.

Several models have been proposed to reflect the time growth of cumulative sales over time. Mahajan and Muller (1979), Hurter and Rubenstein (1978), Sharif and Ramanathan (1981) provide excellent overviews of these developments.

Several existing models of technological forecasting may prove specially useful for monitoring the growth in effective demand for a new industrial product (Blackman, 1974; Fisher and Pry, 1971; and Floyd, 1968).

The Blackman model may be viewed as a special case of the Fisher-Pry model. The former considers an upper limit on the share of potential that the new product can capture in the long run whereas in the Fisher-Pry model this upper limit is equal to the market potential.

The underlying concept of the Fisher-Pry model is that, when a new product or process replaces an older one, the rate of adoption is proportional to the interaction of the fraction of the older one still in use and the current level of penetration. Mathematically, this relationship can be expressed as follows:

$$\frac{df}{dt} = bf(1-f) \qquad (1)$$

where f = fraction of potential market having adopted the new product

b = a constant, characterizing the growth in effective demand for a particular product technology.

Integrating (1) yields a logistic curve:

$$f = \frac{1}{1+e^{b(t-t_o)}} \qquad (2)$$

where t_o = time when adoption of the new product has penetrated half the market and

t = measured as time since introduction in years.

This last equation can be conveniently rewritten as:

$$\left(\frac{f}{1-f}\right) = e^{b(t-t_o)} = e^{b_o+bt} \tag{3}$$

Exhibit 3 demonstrates how the (log linear) form of Equation (3) fits the data for a number of new industrial products and processes. The Fisher-Pry model has been demonstrated to work quite well, using data from when a new technology has replaced an older one. As a predictive tool, when little data is available, and when it is unclear that one technology will completely substitute for another one, it needs to be adapted.

The work of Blackman et al. (1973) and Blackman (1974), building upon the work of Mansfield (1961, 1968), provides methodology to make projections for substitution in the absence of an adequate historical data base.

The Mansfield-Blackman model, written in the same form as (3) above is as follows:

$$\left(\frac{f}{F-f}\right) = e^{b_o+bt} \tag{4}$$

where F = upper limit in the potential market that the new product can capture in the long run.

Mansfield's important contribution was the decomposition of the constant b, above. He argued that b should be higher when (a) the relative profitability associated with the new product is high and (b) when the initial investment is low. In studies of diffusion in disparate industrial sectors including railroads, coal, steel and breweries, he found an empirical expression for b as:

$$b = Z + .53\pi - .027S \tag{5}$$

where Z = an industry specific constant

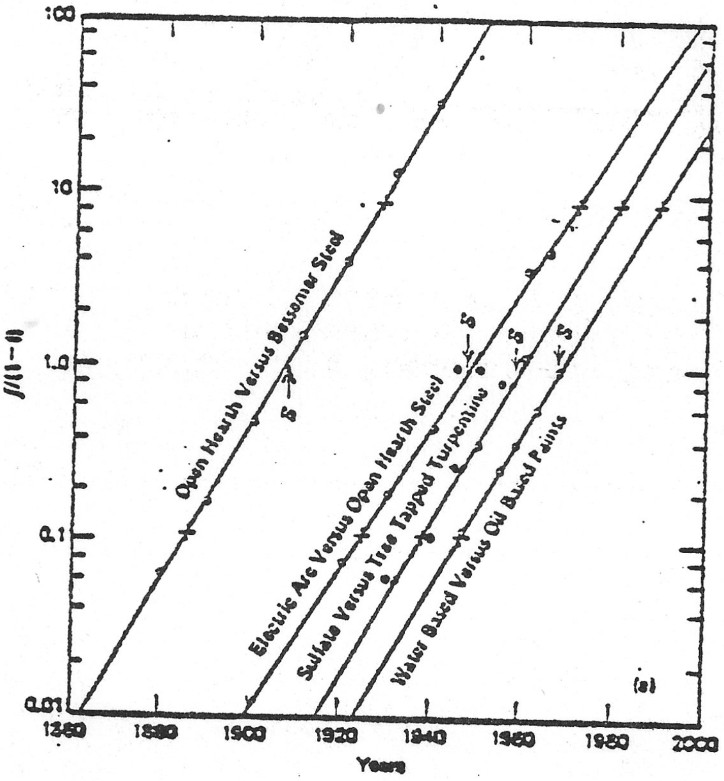


Exhibit 3 Substitution data and their fit to the Fisher-Pry model for a number of products and processes

Π = estimated rate-of-return associated with the innovation divided by the minimum rate-of-return for investment (i.e., the hurdle rate)

S = initial investment in the innovation x 100 divided by the total assets of an average firm adopting the innovation.

A critical term in this expression is still Z. Blackman's et al. (1973) contribution was to relate the industrial innovation coefficient Z to more general industry coefficients. They create an industry coefficient index (I) which is derived as follows:

- They create a matrix of eight general measures of industry innovativeness -- such as R&D expenditures, current and planned, new product sales as percent of total, value added, etc. -- for each of a dozen industrial sectors.
- They factor-analyze this matrix to obtain a set of factor scores for each industry.
- They regress the score for the first factor (I) against the value of Z to obtain:

$$Z = .222\ I - .316 \qquad (6)$$

In order to use this model for prediction, the following must be known or estimable: the initial level of market penetration (i.e., market-entry assumption), the ultimate level of penetration and the economic consequences of adopting the innovation. Note that Π, S, and I may all vary with time over the life of the innovation, and may need to be modeled as such.

4. APPLICATION 1: MARKET ASSESSMENT FOR ACTIVE SOLAR COOLING

4.1 Background

This application integrates the DESIGNOR methodology within a dynamic framework, aimed at evaluating the likely market for solar powered cooling. The application has two unique elements: (a) it demonstrates how the DESIGNOR concepts lead to a time-varying market potential that can be incorporated, along with technological and economic assumption, in a diffusion model and (b) it shows the value of these tools for government policy planning.

Solar-powered air conditioning represents a technology that could meet some of the anticipated space cooling needs of the 1980's and 1990's (Warren and Wahlig, 1982). Presently, market penetration is hampered by a number of factors, primarily the high first cost of solar relative to conventional space cooling equipment. For example, Warren and Wahlig (1982) estimate the current cost of a 25-ton solar system with enough collector area to operate at half-peak load, to be about $110,000. This compares to $18,000 to $25,000 for a conventional 25-ton unit. Major cost reductions during the next two decades may reduce this gap somewhat.

In the analysis outlined below, we consider what combination of fuel escalation assumptions, solar cost decline assumptions and federal incentives (subsidies) are required to make solar cooling viable by the year 2000.

4.2 Assumptions and Methodology

Several assumptions drive the analysis here. These include:

A.1 Solar cooling is an HVAC investment. The technology is novel, but the need (space cooling) is not. Solar cooling is expected to share existing demand in the cooling market place.

A.2 The major solar market will develop in commercial buildings in census regions 3, 4, 6, 7 and 9. Commercial buildings are most appropriate for solar cooling for technical reasons (lack of feasible, residential technology) as well as due to their large cooling loads. The noted census regions cover the sunbelt -- the high growth regions with long cooling seasons.

A.3 The total cooling market is assumed to be all new construction plus 5 percent (assuming a 20-year life) of existing equipment.

Data required to run the analysis here include: projected cooling energy use by region and building type, projected fuel costs (and ranges), projected costs of conventional cooling equipment, insolation (sunshine) rates, cooling season lengths by region. In addition, a number of assumptions about current and projected cost declines for solar cooling are included. (Johnston and Lilien, 1982, provides details.)

The model used here is outlined in Exhibit 4.

Box (a) - Provides the assumptions for solar technology/performance, subsidy level, and fuel cost escalation for each run of the model.

Boxes (b) - Incorporates the data outlined above (b.2) in a payback/ROI calculation for an investment in solar cooling for each year, 1980 to 2000.

Box (c) - Is the DESIGNOR methodology, estimating market potential as a function of economic life, warranty period, land availability and payback acceptability. (See Lilien and Johnston, 1980, for details.)

Box (d) - Is the diffusion model methodology, estimating the substitution % as a function of the prior year's substitution and the current relative payback/ROI.

Box (e) - Estimates penetration (sales) as potential times substitution percentage

For the purpose of this analysis, a discrete form of the Fisher-Pry (1971) model was used:

$$F_2 - F_1 = b(1-F_1)F_1 \quad (7)$$

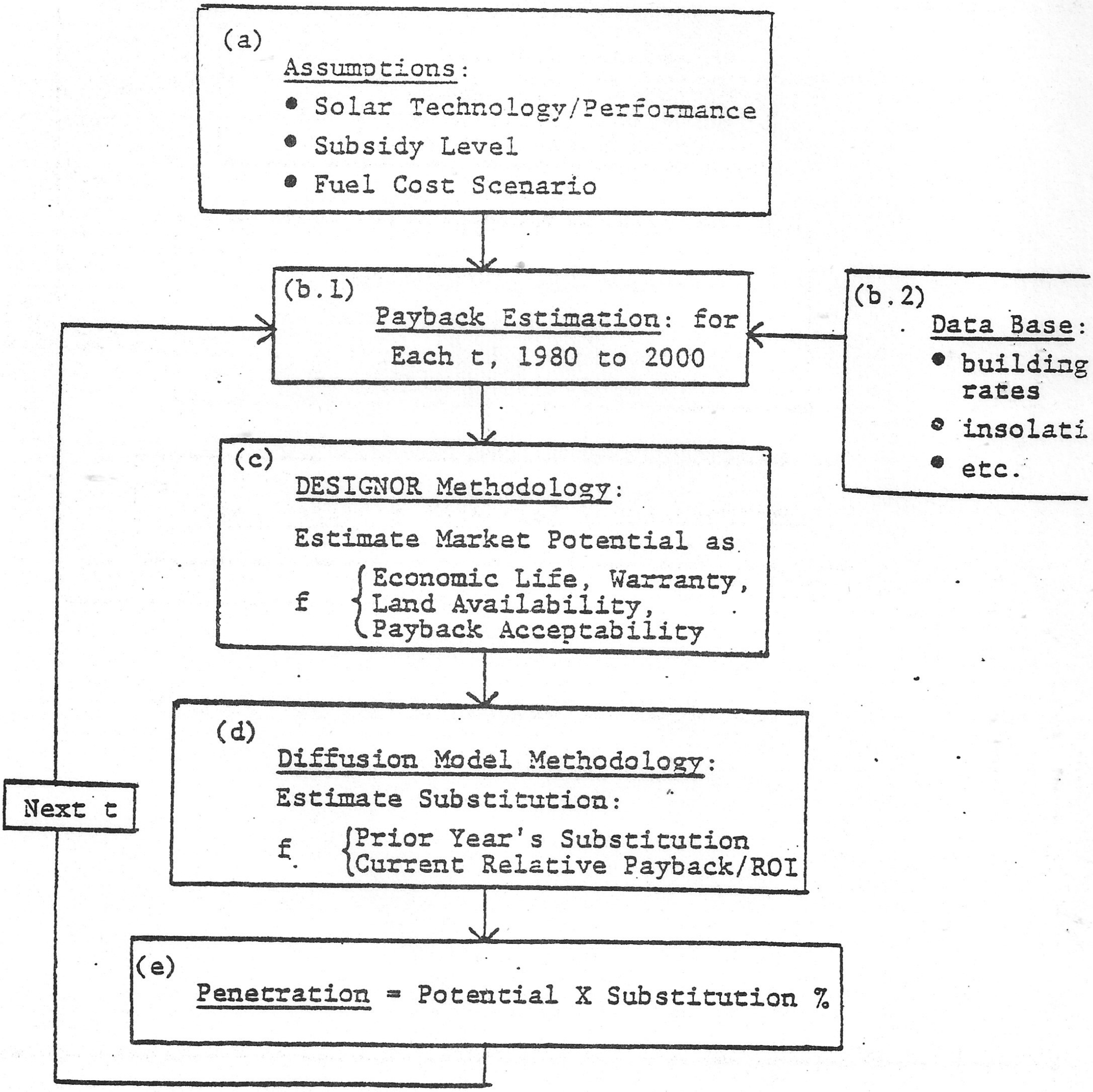


Exhibit 4 Market penetration methodology

where F_2 = penetration % at time 2

F_1 = penetration % at time 1

b = control constant (as in Equation (10).

We took here, as a value for Z in Equation (10), an average industry innovation rate = 0. We modeled π as the median acceptable payback period (4 years, Lilien and Johnston, 1980), divided by the actual payback. We assumed that S is small enough ($\approx$0) so that it can be ignored, a best-case situation.

4.3 Results

Exhibit 5 gives the results of a few sample analyses, for the "mid-range" oil price increase scenario. Only two extremes (optimistic and pessimistic) cost decline scenarios are presented for solar cooling. Even for the optimistic cost decline scenario, without federal subsidy (case 5), solar cooling can only expect to see 2 percent of the market in the year 2000. Other cases are similarly pessimistic; a rather high level of subsidy (20 percent; case 6) only increases that year 2000 share to 9.6 percent.

The conclusions and recommendations from that study were:

> "Based on the results of the solar cooling penetration analysis we see that only under very optimistic cost-reduction assumptions coupled with significant levels of government subsidy will a market for solar cooling develop in the commercial sector. For the market to persist, the subsidy would have to be continued indefinitely; if the subsidy were to be discontinued the market would essentially disappear. World oil prices will have an effect on the market, but even under the most pessimistic outlook for oil price escalation solar air conditioning would have to be subsidized to attain and hold a significant market share . . ."
>
> ". . . It thus appears that only for non-economic reasons should solar cooling technology be supported by subsidy at this time. Indeed, only if research efforts propose to meet or exceed the most optimistic cost-reduction assumptions used in this analysis does it appear that funds for development should be allocated to a solar cooling program." (Johnson and Lilien, 1982,

Case	Energy Savings	Cost[a]	Subsidy	Units[b]	Share[c]	Gov't Cost X $10^6$$
1	nil	A	-0-	226	.06	-0-
2	nil	A	.2	611	.2	-0-
3	nil	A	.35	2023	.6	-0-
4	nil	A	.5	12825	3.8	596
5	nil	E	-0-	5185	2.0	-0-
6	.02 quad	E	.2	26345	9.6	257
7	.06 quad	E	.35	60096	18.9	1054
8	.12 quad	E	.5	93735	22.4	2432

[a]Cost Decline Assumption
A = No Price Decline (Pessimistic)
E = 50% Cost Decline (Optimistic)

[b]Equivalent 25-Ton Systems

[c]Share in Year 2000

Exhibit 5 Mid-range oil price scenarios: year 2000 results

5. APPLICATION 2: MARKET ASSESSMENT OF BRANDED EXPANDABLE CEMENT

5.1 Background

Cement is a product that is several hundred years old and is perceived to be essentially a commodity. New products have come from outside the cement industry and compete with cement in a market that has been shrinking in the last few years. Chemical firms have become interested in possible substitution products such as resins and performance enhancement products such as adjuvants.

In 1974, a leading European cement manufacturer considered differentiating its offerings for some industrial applications. A new ready-to-be-used, expansion-contraction resistent cement was designed and tested in a large European market for a year. A decision had to be made whether to expand the product line and to plan production capacity and marketing strategy accordingly.

5.2 Methodology

Assessment of the market potential for the new product was carried out by two parallel methods including a version of the DESIGNOR methodology, and the extrapolation of the dynamics of market acceptation, as observed during the first year of commercialization of the new product.

Assessment of the potential market for the new product proceeded in three steps.

- Target Market Definition. The target market was defined as those industrial firms whose activity and size were thought to be more conducive to the use of the new product. Prior internal market research indicated that several thousand companies formed the target market for this product in the region considered.

- Market Potential Assessment. A survey was made of a representative sample of target firms to assess acceptance of the new product's features, awareness of its existence, and some measures of interest about adopting it for specific applications. Current product usage was measured two years. Exhibit 6 summarizes the different results of the DESIGNOR analysis performed at that stage.

- Assessment of the Time Growth of Sales. Along with the survey, a generalized logistic model was calibrated on the smoothed series of monthly sales data. This model has the following analytical form:

$$\frac{ds}{dt} = (\alpha + \beta S_t/\bar{S})(\bar{S} - S_t) \tag{8}$$

where S_t = cumulative sales at t

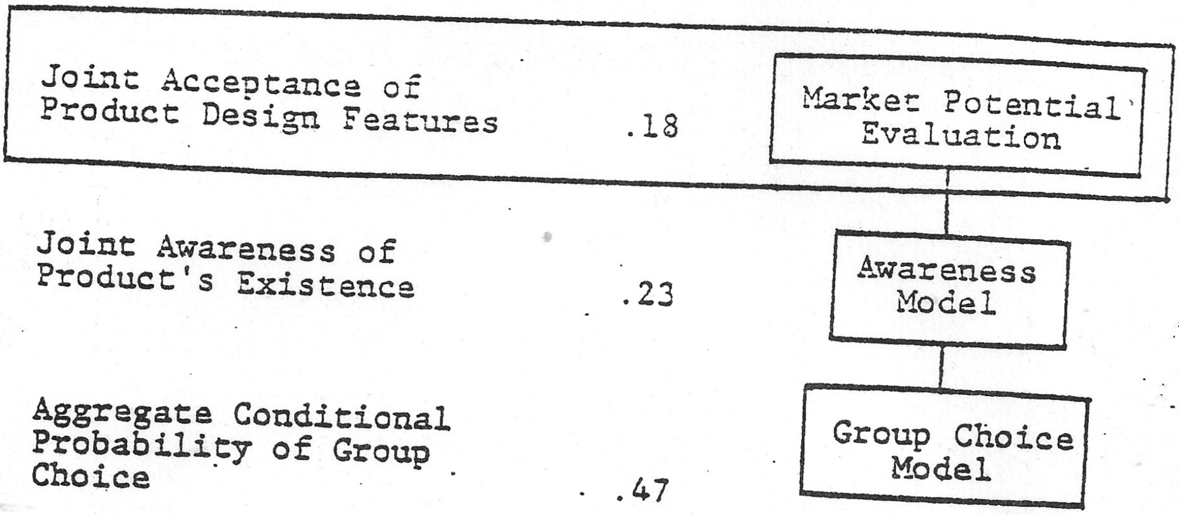
S = upper limit on penetration (sales potential)

α, β = parameters to be estimated

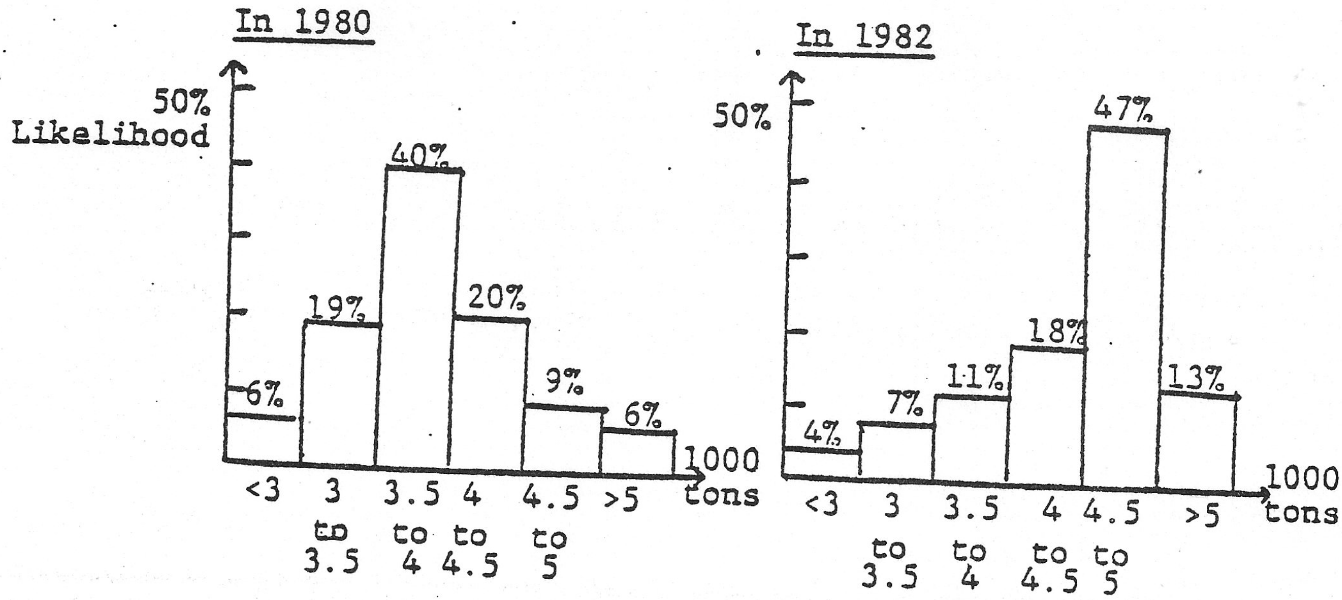
Exhibit 10 summarizes the main managerial results of this analysis.

Consideration of the results in Exhibits 6 and 7 led the firm to modify its marketing strategy as well as its planned production capacity development in 1979. Following the analysis made of the response of the market to this change, a new product was developed and introduced in 1981. We reproduce in Exhibit 8 the simulation that was performed to assess the time growth of likely sales for this new product. Adding value through technical assistance accelerates the diffusion process, allowing a fuller use of available capacity. Both programs were adopted by the firm in its new strategy.

6 a DESIGNOR Analysis Results



6.b Empirical Distribution of Projected Demand



Total Market Potential (Expected Value) = 38,000 tons

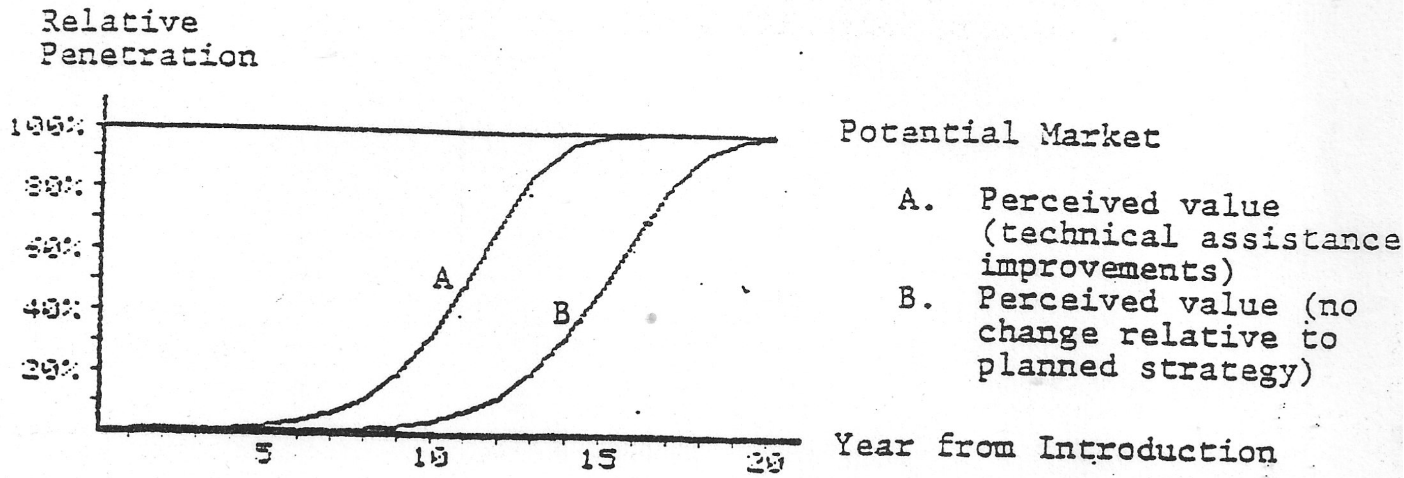
Exhibit 6 Market potential evaluation for a new cement

Market Potential Assessment: 38,000

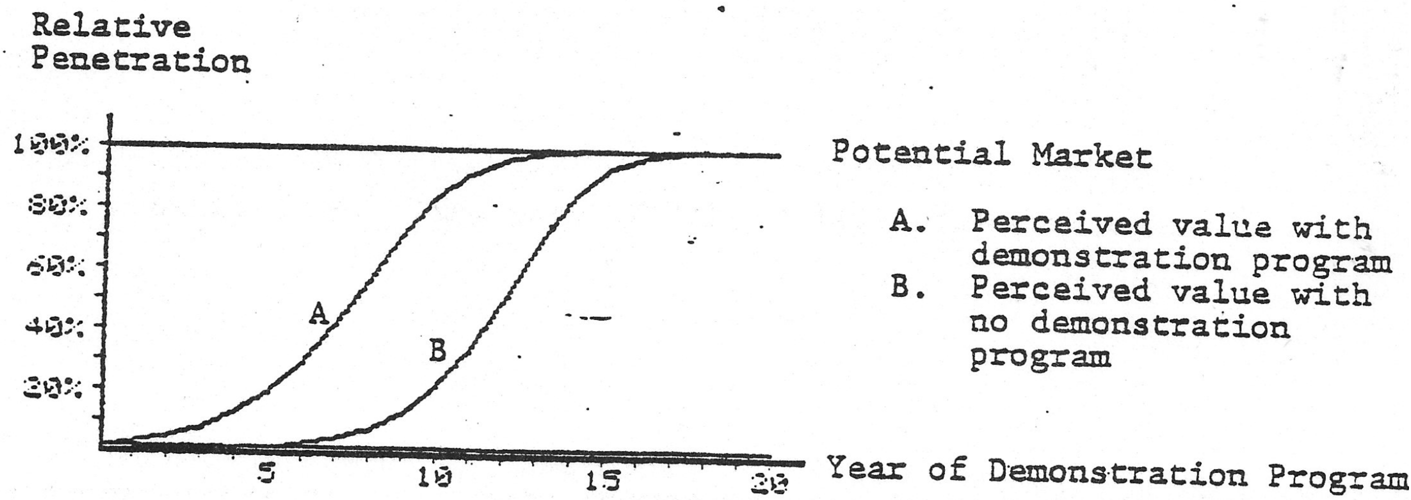
Time Path of Actual and Projected Annual Sales

	1978	1979	1980	1981	1982	1983	1984
Forecast	1686	2822	3746	4486	4944	4942	4480
						▲ Sales Peak	
Real	1662	3160	4132	4837			
		▲ Marketing Strategy Change		▲ Seconol Product Introduction			

Exhibit 7 Time based demand forecasts for the new cement



8a - Impact of enhanced product value on the likely diffusion process



8b - Impact of demonstration program on the likely diffusion process

Exhibit 8: Time path of likely sales for a new cement

6. DISCUSSION AND CONCLUSIONS

The analytic approach developed here has been used for a wide variety of industrial products including large industrial water pumps, computer assisted accounting systems, commercial curtain walls, frozen complete institutional meals, intelligent terminals, photovoltaic (solar electricity) systems, and others. The methods provide support for two key steps in the new industrial product process: design and market forecasting.

The level of use of these types of tools in industrial markets is low. Little and Cooper (1977) report that for more than half of a sample of new product projects less than two hours of market assessment was conducted for every $1,000 of expected annual profits. This situation should change with the continual increases in the cost and risk of new industrial product design and development. Choffray and Lilien (1983) report on the development of new tools to support the launch decision.

The approaches outlined here are new and will take time to become standard practice in industry. In the meantime, forward thinking industrial firms will take the lead by adopting these new approaches, and make early use of them to reduce new product development costs and risks.

REFERENCES

Blackman, A. Wade, Sr. "The Market Dynamics of Technological Substitutions." Technological Forecasting and Social Change, Vol. 6, No. 1 (1974) pp. 41-63.

Blackman, A. Wade, E. J. Seligman and G. C. Solgliero. "An Innovation Index Based Upon Factor Analysis." Technological Forecasting and Social Change, Vol. 4 (1973) pp. 301-316.

Booz, Allen and Hamilton. Management of New Products. New York: Booz, Allen and Hamilton, Inc., 1971.

Choffray, Jean-Marie and Gary L. Lilien. Market Planning for New Industrial Products. New York: Wiley, 1980.

Choffray, Jean-Marie and Gary L. Lilien. "Forecasting Sales and Evaluating Launch Strategies for New Industrial Products." Penn State University Working Paper, October, 1983.

Choffray, Jean-Marie and Gary L. Lilien. "DESIGNOR: A Decision Support Procedure for Industrial Product Design." Journal of Business Research, Vol. 10, No. 2 (September 1982) pp 185-197.

Crow, Lowell E., Richard W. Olshavsky and John O. Summers. "Industrial Buyers' Choice Strategies: A Practical Analysis." Journal of Marketing Research, Vol. 17 (February 1980) pp. 34-44.

Fisher, J. C. and R. H. Pry. "A Simple Substitution Model of Technological Change." Technological Forecasting and Social Change, Vol. 3 (1971) pp. 75-88.

Floyd, A. "Trend Forecasting: A Methodology for Figure of Merit," J. Bright, ed., Proceedings of the First Annual Technology and Management Conference. Englewood Cliffs, N.J.: Prentice Hall, 1968.

Green, Paul E. and V. Srinivasan. "Conjoint Analysis in Consumer Research: Issues and Outlook." Journal of Consumer Research, Vol. 5 (September 1978) pp. 103-123.

Green, Paul E. and Y. Wind. Multi-Attribute Decisions in Marketing. Hinsdale, Ill.: The Dryden Press, 1973.

Hopkins, David S. "New Product Winners and Losers." The Conference Board, Report No. 773 (1979).

Hurter, Arthur P., Jr. and Albert H. Rubenstein. "Market Penetration by New Innovations: The Technological Literature." Technological Forecasting and Social Change, Vol. 11 (1978) pp. 197-221.

Johnston, Paul E. and Gary L. Lilien. An Integrated Planning Structure for Commercial Applications of Active Solar Cooling: Methodology and Analysis. Final Report prepared for Active Building Systems Branch, Office of Solar Applications for Buildings, US Department of Energy under DOE contract DE-AC03-81CS30571, May 1982.

Lafeuille, D., Difficultes et Blocages dans Le Processus d' Industrialisation des Innovations (Paris, I.T.E.I.) 1981.

Lilien, Gary L. and Paul E. Johnston. A Market Assessment for Active Solar Heating and Cooling Products, Category B: A Survey of Decision Makers in the HVAC Market Place. DOE Contract No. AC03-79CS-30209, September 1980.

Little, Blair and Robert Cooper. "Determinants of Marketing Research Expenditures for New Industrial Products," Industrial Marketing Management, Vol. 6, No. 2 (1977).

Mahajan, Vijay and Eitan Muller. "Innovation Diffusion and New Product Growth Models in Marketing." Journal of Marketing, Vol. 43 (Fall 1979) pp. 55-68.

Mansfield, Edwin. "Technical Change and the Rate of Imitation." Econometrica, Vol. 29, No. 4 (October 1961) pp. 741-765.

Mansfield, Edwin. Industrial Research and Technological Innovation. New York: Norton, 1968.

Mansfield, Edwin and John Rapoport. "Costs of Industrial Product Innovations." Management Science, 21 (August, 1975) pp. 1380-1386.

Mansfield, Edwin and Samuel Wagner. "Organizational and Strategic Factors Associated with Probabilities of Success in Industrial R&D." The Journal of Business, 48 (April 1975).

Office of Economic and Cultural Development. Gaps in Technology: Scientific Instruments. Paris, 1977.

Piatier, A."Les obstacles à l'Innovation dans les pays de la Communaute Europeene" (Luxembourg, Commission des Communautes Europeene.) 1981.

Sharif, M. N. and K. Ramanathan. "Binomial Innovation Diffusion Models with Dynamic Potential Adopter Population." Technological Forecasting and Social Change, Vol. 20, No. 1 (August 1981) pp. 63-87.

Urban, Glen L. and John R. Hauser. Design and Marketing of New Products. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1980.

Warren, Mashuri L. and Michael Wahlig. Cost and Performance Goal Methodology for Active Solar Cooling Systems. Lawrence Berkeley Laboratory Report LBL-12753, under DOE Contract W-7405-ENA-48. February 1982.

Webster, Frederick E., Jr. and Yoram Wind. Organizational Buying Behavior. Englewood Cliffs, N.J.: Prentice-Hall, 1972.

Wind, Yoram J. Product Policy: Concepts, Methods and Strategy. Reading, MA: Addison-Wesley, 1982.