NASA's Space Shuttle: Policy Decisions in the Wake of Kondratieff Wave Interactions

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Industrial opportunities and contributions to life's quality made possible through the U.S. fleet of space shuttles could be immense. Public policy decisions pertaining to that technological innovation will profoundly influence the timing and extent of its effects on domestic and international competition, and on our society. Through a far-sighted marketing orientation, public policy makers can cooperate with industry to achieve a timely synergistic result.

As space fantasies abound in the media and as numerous scientists, academicians, and social critics of various persuasions focus on what the future will hold for mankind, the National Aeronautics and Space Administration (NASA) has launched the world into what could become another industrial revolution through utilization of outer space. Significant marketing implications ensue, not simply for particular industries by developing opportunities from a gravity-free environment and from the vast resources of space, but for all of mankind. As consumers of space resources, as those who must bear opportunity costs of undeveloped space potentials, and as members of organizations subject to the competitive environment and the economy which inevitably will be altered by such a revolution, we will all be affected.

A few key opportunities among the vast number of potential benefits that an outer-space environment will afford industry, government and consumers are:

- Some observers foresee solar power satellites which would convert sunlight into energy and then beam it to earth.
- Studies have sought to determine the feasibility of nuclear waste disposal into outer space.
- Electrical fields in zero-gravity have been demonstrated to produce drugs inexpensively which at present cannot be made on earth.
- Larger and more serviceable satellites may be placed in space along with the possibility of recovering these and other space resources [Hertzfeld 1980].

Abatement of serious environmental concerns, alternatives to or supplemented supplies of scarce terrestrial resources, and more efficient and higher quality production capabilities await our effective utilization of space. The orientation our government pursues in developing outer-space policy will determine the speed, extent, and pervasiveness to which such societal benefits are achieved.

Innovation and Improved Technology

Constant innovation is necessary for the United States to retain its threatened international position of industrial and marketing leadership. Unfortunately, the nation's rate of productivity has slipped during the seventies, from an average annual increase of 3.2 percent per year during 1947–66, to 2.1 percent during 1966–73 and 0.8 percent during 1973–79 [Bowen 1979].
Data on new patents show comparable trends, with 56,000 in 1971, and 44,482 in 1978. Research and development expenditures as a percent of gross national product have also decreased from 3 percent in 1964 to 2.2 percent by 1978 [Time 1979], and are expected to remain at that level for the near future [Clauser 1980, p. 2].

U.S. decline in applied science and innovation can be blamed partially on the economic downturn which characterized the seventies. Strategic, as well as tactical, business decisions reflecting that economic trend have become more defensive, cost-cutting, and short-run. The lack of a unified and well-planned national policy on technological innovation can be cited as further contributing to the impairment [Greene and Miesing 1984].

Another reason for decline stems from resources diverted from basic and applied research and development in order to comply with complex government regulation. Additionally, the feelings that the risks of R & D are considerable, lead-time is long, benefits are unknown, and the advantages of such expenditures often accrue to others, contribute to increasing risk aversion by many entrepreneurs.

Though typically unpredictable, the full impact of technological breakthroughs on society and the returns to it can be immense. However, economic feasibility can preclude businesses from investing large R & D expenditures when market forecasts do not convincingly justify the cost, or when the effort appears too great. In that vein, to use space effectively, high-technology companies and NASA need one another. While government can provide basic research and the means to access space, inherent competition and profit incentives will stimulate free enterprise to best determine optimal applications of new technologies. Statements before the U.S. Congress echo the fundamental necessity of this government-private enterprise interaction:

Private sector innovation and creativity in product and process applications, as well as understanding of market needs, dictate the importance to the Nation of early participation from broad and diverse industries and businesses [U.S. Congress, House 1979, p. 1].

This symbiotic relationship has accomplished an effective transference of technology developed from NASA's aerospace programs into improvements for everyday life. Numerous structures constructed with fabric have embodied aerospace research, such as the air-supported domed roof over the Detroit Lions' Silverdome, utilizing a fiberglass fabric originally developed for astronauts' space suits. Ground fault interrupters, which provide protection against electrical shock, were derived from space technology and are now required devices in all newly constructed homes. NASA's Annual Report series offers examples of aerospace technology transfer to such fields as agriculture, recreation, health care, and many others.

NASA's shuttle venture involves more than nonprofit marketing, for its technology has a direct impact on United States' marketing, both domestically and internationally. That impact affects individual businesses within industries by altering the potential for improved efficiencies and the opportunities for truly original product offerings. Shuttle technology likewise changes the nature of interindustry competition, and can have increasingly significant effect on our overall business environment. The timing and extent to which those direct effects engendered by the space shuttle reach fruition are influenced by and have an influence upon economic cycles, especially when the parameters of such an innovative scientific breakthrough are exceptionally pervasive.
Pruden [1978, p. 69] commits to investigation of those cycles as marketing's domain.

The study of the wave-like motions of capitalism is the rightful province of marketing. The cyclical contours of capitalism emanating from private property, innovation, bank credit, tides of optimism and pessimism, industrial structure, etc., are played out in the marketplaces—the marketplace for goods and services, the financial marketplace, and the marketplace for labor. It would seem natural that a study of the dynamism of the marketplace would lie close to the heart of a proper study of marketing.

Correspondingly, management strategies for contending with business and other cycles in our economy are the rightful province of marketing, along with other disciplines. The marketplace hosts the effects from those cycles.

Anticipation of probable effects on economic cycles from technological breakthroughs should represent salient inputs for forecasting and for marketing strategies by individual firms. If technology arising from the space shuttle was expected to amplify a cyclical upswing or dampen a downswing, a firm's sales potential and specific marketing opportunities could change significantly, even though the firm was not involved directly with shuttle technology. Such changes would then warrant revision of forecasts and strategies.

The aforementioned strategic responses by businesses to anticipated deviations from normal patterns of economic cycles result from expectations that progressive firms will invest in opportunities emerging from a scientific breakthrough. Firms recognizing the potential from a gravity-free environment and from other facets of shuttle technology can be expected to invest more heavily in R & D as well as in additional dimensions of new-product marketing than they would if that technology had not been developed. Thus, a technological breakthrough can generate at least first and second order influences on economic cycles: the first coming from firms investing directly in the new technology, and the second coming from companies with expectations that the first set of firms will enhance the economic climate for businesses.

Marketing decisions, therefore, could affect the magnitude and inflection points of various economic cycles. Actions, and anticipation of actions in the financial marketplace, the marketplace for labor, and the market for research and development activity are capable of exacerbating or ameliorating cyclical effects. Public policy makers have a unique opportunity to encourage those actions and thereby enhance the economic climate for businesses, through widespread promotion of innovative scientific technologies. Through effective promotion, government officials could magnify technology's benefits to society and the business environment, with actions by firms and the anticipation of still further actions spurring even greater business investment and additional improvement of cyclical economic effects.

Pruden asserts that one such cyclical effect, the Kondratieff Wave or long cycle theory, may well account for much of our current economic and social conditions. He cautions that the U.S. economy, according to the long cycle theory, has moved beyond the peak of the current 54-year Kondratieff Wave, "and we are now going downward and will continue to go downward for two to three decades" [Pruden 1978, p. 63]. Opportunities created by the U.S. shuttle fleet will be at the same time affected by and have an effect upon such economic conditions. A discussion of the Kondratieff Wave and major criticisms levied against its theoretical and statistical
underpinnings will help to clarify its possible interaction effects with space shuttle technology.

The Kondratieff Wave is one of many cycles postulated by econometric studies, including the so-called "business cycles." Dewey and Dakin [1947] cite four cycles which statistical analysis indicates have enjoyed acceptance by analysts:

1. Kitchen Cycle—40 months' duration
2. Juglar Cycle—9 1/4 years' duration
3. Kuznets Cycle—18 1/4 years' duration
4. Kondratieff Wave—54 years' duration

Taking all four into consideration and treating each longer cycle as the trendline about which the next shorter cycle fluctuates, Pruden [1978, p. 64] states:

It is assumed that the longer the duration of a cycle, the greater the amplitude and, thus, the more important its impact. In this sense, the crucial cycle is the 54-year Kondratieff Wave.

Nikolai Dmitrievich Kondratieff, of the Agricultural Academy and the Business Research Institute of Moscow, first wrote about his theory of long cycles in a very cautious manner [Kondratieff 1922]. Through a series of books and papers written between 1922 and 1928 he progressively developed the theory and replied to a glut of criticism from fellow Soviet Russian economists. Utilizing econometric analyses of various time series, dating from the late 1780s to the early 1920s and based on series from England, France, Germany, and the U.S., Kondratieff declared that the available data was sufficient to indicate the existence of long cycles between 48 and 60 years to be "very probable" [Kondratieff 1925].

In addition to suggesting dates of peaks and troughs for the first three waves (displayed in Exhibit 1) based on his statistical time series analyses, Kondratieff also developed a theoretical basis for the origin and dynamics of long cycles. To strengthen his quantitative conclusions, "we must supplement our analysis by the study of concrete features of the evolution of the capitalist system i.e. . . . ." [Kondratieff and Oparin 1928, p. 37], Exhibit 2 lists five empirical characteristics of long cycles, established by Kondratieff as "concrete features." Although he supplied an inventory of events and inventions to document those five characteristics, he stressed that a causal relationship could not exist between those exogenous characteristics and the long cycles.

Instead, long waves were attributed to noncontinuous spurts of invest-

<table>
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<th>Exhibit 1. Dates of Kondratieff Waves*</th>
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<td><strong>First Wave</strong></td>
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<td>Trough and beginning of incline</td>
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<td>Peak and beginning of decline</td>
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*Adapted from Pruden (1978) and Garvy (1943). Kondratieff's calculations allowed for a variance between 48 and 60 years in the cycle.
Exhibit 2. Empirical Characteristics of Long Cycles*

1. Before beginning the long upswing—profound changes in economic life take place, consisting of:
   a. changes in technology (preceded by important discoveries and inventions),
   b. inclusion of new countries in the world economic system,
   c. changes in gold production and monetary circulation.
2. During the long upswing—most social upheavals take place (e.g., wars and revolutions).
3. During the long upswing—business cycles are characterized by short depressions and intense rises.
4. During the long downswing—business cycles are characterized by intense depressions and short rises.
5. During the long downswing—agriculture suffers an especially pronounced and prolonged depression.


ment in the "fund of basic capital goods" (e.g., large plants, railways, and canals). Such large investments require significant amounts of loanable capital, necessitating the following conditions before a major upswing can begin:

1. High propensity to save
2. Relatively large supply of loan capital at low rates
3. Its accumulation at the disposal of powerful entrepreneurial and financial groups
4. A low price level, inducing savings and long-term capital investment [Kondratieff 1928, p. 38]

Economic expansion, fed by applications of inventions from the preceding phase, reaches an upper limit at increased interest rates and actual capital shortage. The lower turning point of the cycle was not explained [Garvy 1943, p. 208].

Throughout the development of his long cycle theory, Kondratieff met with generally unfavorable reviews from his contemporary Russian economists. The violent nature of much of that criticism can be attributed to the alleged "apologetic character" of Kondratieff Wave Theory, in that the theory implies a continuous, normal evolution of the capitalistic economy, with long and short cycles being temporary deviations. As such, the period 1914–20 became simply the beginning of a downswing of a long wave, rather than a period of wars and revolutions preceding final disintegration of the capitalist economy, as expected by Soviet Russian leaders. Despite bias from those Russian economists, they adduced many important arguments in denouncing the long cycle theory. The following is a summary of their major criticisms.

- What the eliminated trend stands for is not clearly formulated.
- It is artificial to decompose the economic process into a trend and long waves; the latter are merely results of summing particular business cycles of varying amplitude, which happen to fall within each phase of the long waves.
- Long swings in the economy exist, but they are not cyclical.
- Series selected for analyses were not exhaustive nor logically chosen.
- Though attributed to all aspects of economic life, long waves can be observed only in price and long-term interest rate movements.
NASA's Space Shuttle

- A number of events and series in certain capitalistic countries were counter-cyclical to Kondratieff's Waves.
- Selection and dating of inventories were arbitrary; inventions are not applied only in "clusters," nor introduced only during downswings of a long cycle.
- Some wars and revolutions can be seen as clustering around long wave turning points, and others were equally distributed over different phases of long waves; Kondratieff contended they occurred much more frequently during upswings.
- During business cycles, the proportion of depression and prosperity years may differ in periods of rising prices versus falling prices, but that phenomenon can be accounted for by the price level alone without the hypothesis of long cycles.
- Contrary to the general notion of a cycle, each long wave of the economic system is qualitatively as well as quantitatively different.
- The required proof that the causes of long wave upswings necessarily originate the factors which bring about the following depressions was not manifested.
- Long swings identified by Kondratieff are simply different stages in the capitalist economy's evolution; they are not necessarily repetitive.
- Contrary to the claim that long cycles are international, historically the retardation in development of one economy frequently resulted from the more intensive development of another country's economy.
- Claiming that the long waves are not due to exogenous causes, but are only brought about by endogenous forces is wrong; major swings in economic life must have exogenous causes.
- As opposed to reinvestment as a succession of discrete clusters occurring only during long upswings, the great variation in the life of capital goods and the variety of different kinds of durable goods suggest a continuous process.
- That the application of inventions is subordinated to preliminary accumulation of loanable funds is unrealistic; Kondratieff neglected the possibilities of credit expansion.

To those criticisms Garvy [1943], of the National Bureau of Economic Research, adds the following discerning arguments:

- While asserting that his study would lose much of its force if the behavior of purely physical series were not analyzed, Kondratieff could demonstrate the existence of long cycles in only 11 of 21 production and consumption series which he examined.
- Of the few production series considered demonstrative of long cycles, upon closer examination all of them fail to support the theory.
- Serious questions arise concerning the stability of fitting a least-squares curve to only 2 or 2½ cycles of data; yet of the 25 series in which Kondratieff observed long cycles, only four cover 2½ cycles, four cover 2 cycles and the others cover 1½ or less cycles.
- For the only wage series extending back to the beginning of the first long cycle, the turning points of that series would not be those indicated by Kondratieff if his own rules had been applied directly to that series.
- Less arbitrariness in choice of period to which the trend was fitted, more adequate trend formulas, and closer conformity to his own rules for determining turning points would have yielded a significantly less uniform pattern than the long wave cycles as hypothesized.
- Business cycles alone, of a particularly large amplitude, are likely to determine turning points of what appear to be "long cycles," since the latter were determined from unsmoothed deviations from secular trends; even for smoothed data, business cycle swings of large amplitude influence moving averages sufficiently to produce the illusion of major cycles.
- Even if investment were discontinuous, reinvestment must be continuous since it depends on obsolescence rate, cost of maintenance, interest rates, wages, technical progress, rate of operations, as well as actual wear and tear.
- The theory makes the unlikely synchronization assumption that applications of new inventions occur at the time of replacement of original investment.
because both are subordinated to accumulation of sufficient amounts of loanable capital.

- Kondratieff's assumption that free loanable funds can wait up to a quarter of a century to be invested, remaining unaffected by expansions and contractions of successive business cycles, is unrealistic and could not withstand an empirical test.

If the Kondratieff Wave Theory is believed and we are truly in the downswing of a fourth long wave, tremendously more aggressive promotion of the commercial benefits that can derive from outer-space technology will be necessary. Since even during strong economic times development of innovative technological applications is risky, during economic decline that venture involves much greater jeopardy. As Pruden [1978, p. 67] posits, "Thus, it should not be too surprising that the percentage of GNP devoted to R & D has been trending downward during recent years...." But, in addition to the need for significantly stimulating the use of shuttle-craft technology, it is reasonable to expect a moderation of the depression phase of the current wave.

Alternatively, for those who doubt the validity of long cycle theory and view current economic conditions as the downside of a shorter cycle, the prescription remains the same. While disinvestment appears best to individual firms in a declining economy, the cumulative effect of such policies is an exacerbation of conditions. Whether significant progress toward realizing the potential benefits afforded by an extra-terrestrial environment can be achieved in the near future depends heavily upon our government's ability to market that innovative technology during downswings in the economy. The economic, societal, and industrial benefits made possible by shuttle-craft technology can fully reach fruition only through strong government/industry cooperation, with government taking a far-sighted marketing approach. Greene and Miesing [1984] discuss specifics of public-policy marketing decisions and activities that are necessary to fully realize those benefits.

Being essentially mission-oriented, the success of this country’s federal space agency is measured by its achievement of various goals. Its primary goal is to build a national capability for economically transporting people and materials to and from space. However, applications of that capability presage vast implications for individual firms capable of directly applying that technology to their marketing strategies; for the economic climate of all businesses, which will affect their marketing planning; and ultimately for all of us who in many ways will experience the consequences of those marketing activities.

Policy decisions faced by NASA as guidelines for applications affect our economy and society in pervasive ways. Issues—such as the extensiveness of information dissemination and the nature of that information, barriers of admission to the shuttle, selection procedures, amount of joint government/industry cooperation, and policies on technology transfer among organizations utilizing space—directly influence our marketing systems, altering the nature of competition among and within many industries.

In a relative manner those issues will affect all industries and deeply touch many facets of societal objectives and human life. Decisions concerning the space shuttle demand a future-oriented perspective into unprecedented areas, with a view toward the second, third, and beyond-order effects of those decisions. As we move through the decade of the '80s when technological change can be expected to continue its accelerated
pace, an even deeper and longer-run anticipation of the impact of those changes must be realized than had been in the previous decade.  

Summary and Conclusions

Industrial opportunities afforded by outer-space technology, accessible through U.S. shuttle craft, can revolutionize our economy and society. Solar power satellites, nuclear waste disposal, vastly improved manufacturing techniques, and new supplies of resources represent but a few of the potential advantages awaiting application of that innovative technology. Conditions in our current economy beg for such opportunities, but also indicate resistance to timely applications of that technological breakthrough.

From a worldwide marketing perspective, foreign competitors portend a serious challenge to the industrial and marketing pre-eminence of the United States. Our rates of productivity and of R & D investment have been trending downward. A joint effort by government and private industry is imperative in order to realize the societal benefits from space technology, and to bolster the U.S. position in the international industrial and marketing arenas.

Economic cycles can have a major influence on the extent and timing of R & D investment by companies, and more generally, on our overall environment for marketing activities. Those cycles affect various market places, with reciprocal effects also holding. It is worth examining the nature of the effects of the interaction between the economy and the marketing strategies of individual firms.

Innovative technological breakthroughs offer an opportunity to improve conditions resulting from economic cycles through direct investment by progressive firms in a promising, new technology, and through more optimistic strategies by other firms in anticipation of the increased direct investments. But downsides in economic cycles tend to dissuade businesses from investing, especially in R & D, with its longer run and more risky returns, although increased investment by the private sector could improve economic conditions for businesses. Public policies promoting private sector investment in technological breakthroughs like the space shuttle appear warranted for overcoming the negative effects of economic downturns.

Pruden [1978] suggests that the U.S. economy is on the downside of a major Kondratieff Wave. Such waves or long cycles in the capitalist system are purported to average approximately 54 years in length and to influence significantly the propensity for applying innovative technology. If the U.S. is indeed in the midst of a downswing of a long cycle, or if it is in the decline stage of a shorter cycle, the requirements are clear. Industrial applications of outer-space technology need much stronger marketing efforts from government during economic downturns if they are to achieve their potential benefits to society and to our international position of leadership in a timely manner.

In order to provide guidance to public policy makers, future research could focus on factors to be considered for policy decisions, the specific marketing issues which are entailed, and the processes which would be most appropriate for optimally deciding those issues. The technology is in place, opportunities to benefit mankind and our nation's international posture cry for actualization, and our government is faced with taking bold, unprecedented action toward effectively marketing the technology made possible by the U.S. space shuttle.
Notes
2. These issues are discussed in Technological Innovation: Government/Industry Cooperation (Gerstenfeld 1979).
4. A complete chronology of Kondratieff's works can be found in Garvy (1943). Much of the present discussion of that topic was adapted from Garvy's examination of the statistical and theoretical aspects of Kondratieff's Wave theory.
5. Garvy (1943) provides a rather thorough discussion, with references, of the major Russian criticisms against Kondratieff's methodology and conclusions. This brief summary is based on Garvy's work.
6. First through fourth order effects are discussed in a paper by Fubini (1970).
7. For a perspective on marketing's responsibility for and expected impact upon society as the decade of the '70s was approached, see Lazer (1969) and a special section of the January 1970 issue of the Journal of Marketing, "Marketing in the 1970's: A Symposium," especially Lavidge (1970).

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——— and D. I. Oparin (1928), Bol'she Zicfy Conjunktury (Major Economic Cycles), Moscow.


