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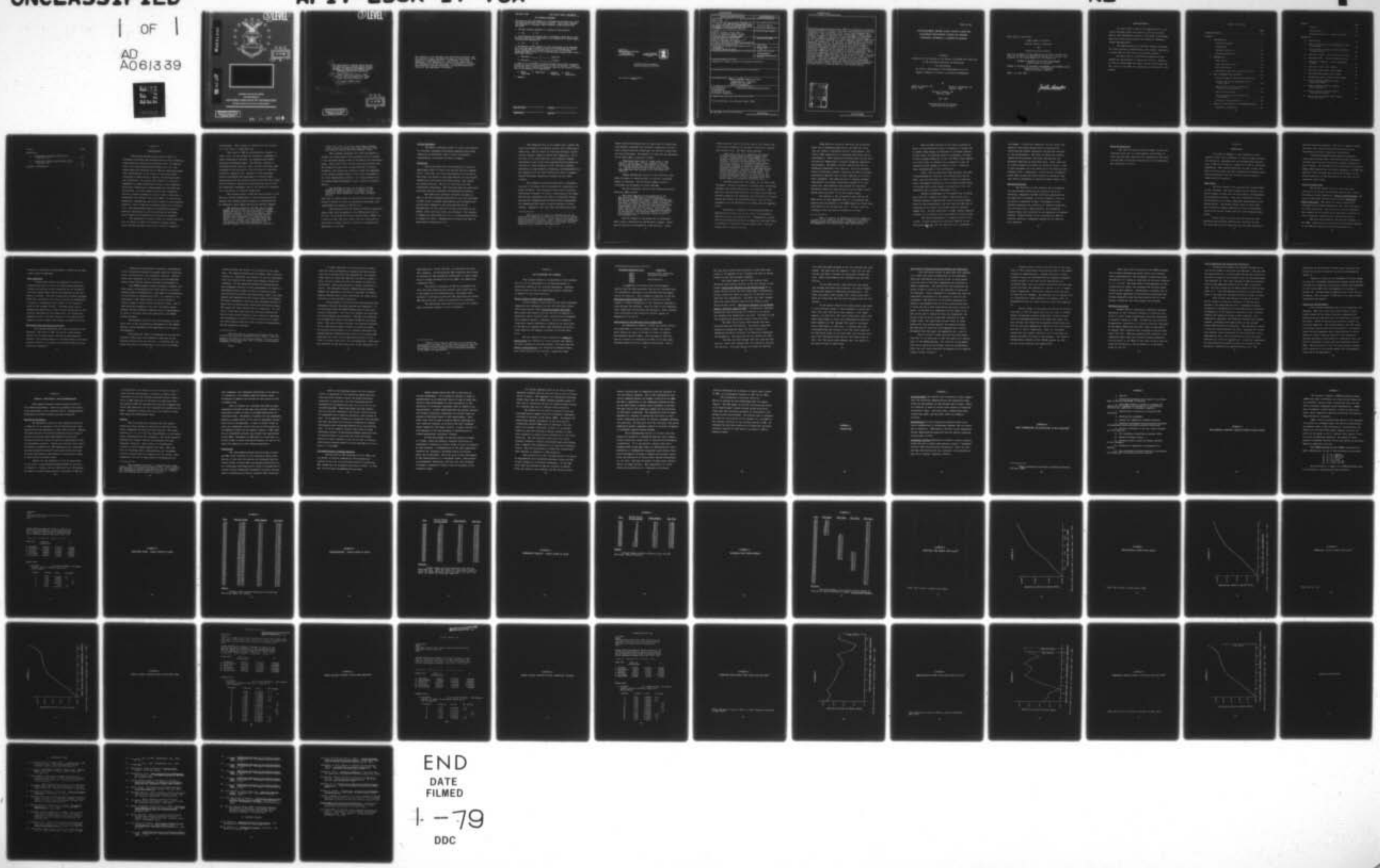

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③ LEVEL II

(6) THE RELATIONSHIP BETWEEN DOLLAR VOLUME OF SALES AND DIMINISHING MANUFACTURING SOURCES FOR SELECTED ELECTRONIC COMPONENTS - A COMPARATIVE ANALYSIS.

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Diminishing manufacturing sources (DMS) is a phenomenon occurring when manufacturers of older technology items gradually discontinue production until, ultimately, there is no known manufacturing capability. The Defense Electronic Supply Center (DESC), which procures electronic components for use throughout the Department of Defense (DOD), is vitally concerned with DMS and its affect in the electronics marketplace. Some measure to predict DMS would be of significant value to the DESC in managing DOD's electronic component inventories. An objective of this research was to test the hypothesis that the relationship between dollar volume of sales and DMS is closely parallel among selected electronic components; therefore, dollar volume of sales for one specific electronic component can be employed to predict electrical component DMS conditions in different but related components. Three electronic components were evaluated in the research effort; receiving tubes, semiconductors, and integrated circuits. Research findings revealed that the growth trend in dollar volume of sales for each of the three components examined followed the linear function. Analysis indicated, however, that the relationship between dollar volume of sales and DMS was not constant among the three components tested, therefore, invalidating the hypothesis that DMS could be predicted based on this relationship.

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THE RELATIONSHIP BETWEEN DOLLAR VOLUME OF SALES AND DIMINISHING MANUFACTURING SOURCES FOR SELECTED ELECTRONIC COMPONENTS--A COMPARATIVE ANALYSIS

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Logistics Management

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MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(Major James D. Corbett)

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(Captain Donald J. McCarthy)
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DATE: 14 June 1978

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COMMITTEE CHAIRMAN

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Chapter 1

INTRODUCTION

Diminishing manufacturing sources (DMS) is a phenomenon occurring when manufacturers of older technology items gradually discontinue production until, ultimately, there is no known manufacturing capability (17). The significance and ramifications of DMS are especially important considerations in the field of electronics where technology is experiencing a rapidly accelerating growth rate (13:43-44). The market-wide demand for electrical components of older technology declines as new components reflecting technological breakthroughs are developed and assimilated. As total demand for the older components declines, private industry no longer finds it judicious to manufacture the outdated items and commits its production capability, engineering, and design talents to more advanced products. Older items are ultimately phased out of production. This diminishing number of manufacturing sources generates challenging logistical problems in providing spares support for sophisticated electronic equipment.

The Department of Defense (DOD) is vitally concerned with the impact of DMS in attempting to support aging weapon systems dependent upon older electronic component technologies. This concern is evidenced by the creation of a task force to study DMS (29).

The causes of DMS are predominately economic in nature (17). As the demand for electronic components of older technologies decrease, the manufacturing market reacts by decreasing supply. The DOD has, because of inflexibility and long lead time, in many instances, been relegated to the position of the sole user of a specific electronic component (3). Because of this monopsony, initial procurement and deployment of a major weapon system, along with the volume of spare parts and the reduced profits potential associated with follow-on sales of the old technology components, may not be sufficient incentive for a contractor to continue production.

The economic basis of DMS and its relevance to the DOD were clearly demonstrated in the following military question and industry answer sequence as interpreted by Mr. Raymond A. Hill, Naval Electronics Systems Command.

> The military question was 'How can a program manager reconcile the fact that while his weapon system may have a life cycle measured in decades, important elements of that weapon system, especially electronics, are being rendered obsolete through rapid advancement of technology every three or four years?' The industry answer was, 'There is no denying that significant problems are created for long-lived products by the natural tendency of a free enterprise industry to

> 'close out' old, low volume, unprofitable product lines in favor of newer, more cost effective items with greater current and future demand' [6:6].

This "natural tendency" of a free enterprise to abandon low volume unprofitable product lines is related to the decreased market power of the DOD in the electronics arena. Since early 1960, when military applications were the primary driving force in semiconductor electronic evolution, the balance has shifted so that the aggregate of all unique military usage is less than ten percent of the total semiconductor market. In a study project for the Defense System Management School, Carrol E. Garrison states:

> One estimate is that, in 20 years, DoD has slipped from being a user of 90 percent of all electrical parts production to being a 10 percent user, while commercial users have increased [6:29].

This loss of market power has reduced the military's capability to direct the flow of mainstream technology, thus compounding the problem of DMS (9:1-2).

DOD Directive 4005.16 charges the Defense Logistics Agency (DLA) with management of the DMS problem (29:1). In turn, the Defense Electronics Supply Center (DESC), as a branch of DLA, has been tasked with the investigation and control of DMS relating to electrical components of importance to the DOD.

Problem Statement

The DESC is presently unable to detect and respond to electronic component diminishing manufacturing source conditions in sufficient time to allow for adequate consideration of alternate methods of supply.

Background

Receiving tubes were first produced for the U.S. Army Signal Corps in 1918 by the Western Electric Company (6:5). Over time, the tubes were improved and refined so that their use spread to such applications as high powered transmitters, micro-wave and radar systems, and cathode ray display devices. The use of receiving tubes has considerably diminished. The functions they had previously performed were soon performed by semiconductor devices.

The transistor (transfer resistor) invented in 1948 in the Bell Telephone Laboratories, has the advantages of small size, low power requirements, and increased reliability when compared to the receiving tube (6:9). Subsequently, as the transistor became established on the market, fewer receiving tubes were produced. The increase in demand for semiconductors led to a corresponding decline in demand for tubes. Manufacturers switched from tube to semiconductor production (17).

The transistor was on the market only a short time before the advent of integrated circuit (IC) technology in 1958 (6:9). The IC, which is even more reliable, as well as more capable, began to replace the transistor. As in the case of the receiving tube, the transistor demand diminished as use of the more sophisticated IC influenced the market. This influence of ICs, the most advanced generation of semiconductor technology, is demonstrated by the capability of one chip[1] produced in 1976, to replace 56,000 individual transistors produced in the 1960s (13:46).

The transition from receiving tube to transistor was made in 40 years; the IC replaced the transistor in a short ten years. The increasing rate of new electronic innovations continues to shorten technological life spans. Difficulties associated with DMS are encountered because some private companies and the DOD maintain requirements for transistors and tubes to support systems of older vintage. Because of the long lead time associated with

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[1]Chip--the word "chip" is commonly used in the electronics community in reference to a sliver of silicon material ¼ inch by ¼ inch, or less, that is the basis of micro-integrated circuitry. Small calculators and digital wristwatches are typical examples of electronic devices employing these miniaturized components.

weapon system development and the rapid pace of technology, some systems, designed with "current" technology instead of newer state-of-the-art technology, are obsolete before they are fully developed. The subject of lead time was addressed by Mr. David Shore, President of RCA:

> Experience shows that it takes eight to ten years to decide on, develop, produce, test, and field a new equipment. Add another ten years for desired use and the total cycle is 20 years . . . by the time we field a new electronic item, key components may already be out of production [16:45].

Weapon systems are subject to the effects of DMS when the number of manufacturers of critical components begins to decrease. The following examples serve to illustrate the problems resulting from DMS.

Mr. Milo Slepicka, Chief of the Technical Services Division, DESC stated:

> The first exposure of any magnitude to the DMS problem at DESC came in 1970 when Wagner Electric announced the closing of their Bloomfield, New Jersey electron tube plant. There were 44 tubes involved, of which 23 were sole source to Wagner. It is evident that the interest and emphasis on the diminishing source problem has escalated significantly during the past few years. I believe, however, that we are still just scratching the surface of the problem. The means and methods to minimize this condition in an economical sense are yet to be developed [17].

Another example is the phase out of germanium, small signal transistors by the Motorola Company. There were 65 national stock numbered items affected. These transistors are used in both the Army's field radios and in the Univac computer of the Navy's ship-board tactical data system (1:6). The DESC group reported:

> Many radios are still scheduled for future production using these germanium transistors. In fact, future production requirements for germanium transistors were almost three million dollars. The end item manufacturer will not invest his money to buy production requirements for future contracts. Therefore, the Army Electronics Command was asked to provide funded documents necessary to cover the requirements for future production. Germanium small signal transistors have gone the way of vacuum tubes. A rather sizeable investment has been made to try to provide adequate support for both future production and repair of radio equipment whose life cycles cannot be accurately predicted [1:3].

The DMS problem does not begin or end with older equipment. Potential problems of support exist concerning equipment and weapon systems not yet operational. The Navy has identified 98 different electronic units that are presently supported by receiving tubes which are in limited supply and without an identified source. Most of this equipment is to be installed on new ships not yet launched (2:5).

Frequently, occurrences of declining numbers of manufacturing sources, as in the case of the germanium transistor, were not predicted (3). Subsequently, scarce DOD dollars have been invested in expensive buys that offer no guarantee of effective future support (20). The following case is typical (1:6,7).

When Motorola initially announced its production phase out of germanium transistors, the DESC was given only two months to determine buy-out[2] requirements. The initial DESC response was to ascertain individual service requirements. Time constraints dictated that the Air Force use historic demand data to project germanium transistor requirements. The Navy's initial response was that no germanium transistors were required. An alert representative of Motorola, however, corrected the Navy's estimate, pointing out specific uses of this component in critical naval equipment. The Army was able to rapidly determine requirements for current operational systems to be supported but, unfortunately, had planned 105 different germanium transistor applications in the new SAM-D missile system which was still in the development phase.

The buy-out is the alternative most used by the DESC and is of such magnitude that it is estimated that greater than ten percent of the DESC budget for Fiscal Year (FY) 1979 will go for buy-outs (17). A large factor in deciding to use the buy-out alternative is time.

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[2]One alternative of assuring sufficient supply of an item in the future is to buy a large once-and-for-all quantity before the manufacturer terminates production. See Appendix B for a listing of other alternatives.

When the DESC receives notice that a supplier is going to stop production there is normally not enough time to pursue other supply alternatives or alternate sources. In this case, the existing supply is purchased, the manufacturer surges production to meet the DOD's final request, or a final order is tendered for a quantity to meet an estimated future demand, whichever is less. There are three disadvantages of this alternative.

First, with an extremely large purchase, the cost of maintaining the inventory over several years can be high. One civilian firm, in order to meet its expected need of germanium transistors over the next several years is storing their entire supply in sealed lots, in a contamination free, nitreous atmosphere (17).

Another disadvantage is the possibility of buying more than will actually be needed. Since there is no DOD-wide system to identify and relate electrical components to end-item products, the best that the DESC can do presently is to project an estimate based on historic demand (20). If this projection is high, tightly budgeted dollars will be wasted on the procurement of excess items.

The third disadvantage is closely related to the second. Because component-to-end-item identity is not maintained there is also the possibility of estimating a low demand. If critical components run out sooner than expected, the weapon system could be operationally restricted and thereby jeopardize the national security of the United States. The Navy, as previously stated, identified 98 different electronic systems that are presently supported by receiving tubes. These tubes are in limited supply and without an identified source. Most of this equipment is to be installed on new ships not yet launched (2:5). Essentially, in the buy-out alternative, scarce DOD dollars are being invested in expensive buys that offer no guarantee of effective future support (20).

Research Objective

The objective of this research was to ascertain the relationship between dollar volume of sales for electronic components and DMS conditions experienced by the DESC and to determine if dollar volume of sales can be used as a predictor of DMS. Achievement of this objective required the collection of industry sales data for receiving tubes, semiconductors, and integrated circuits which were converted to and expressed in constant dollars. Identification of the occurrences of DMS for selected electronic components managed by the DESC was also required.

Research Hypothesis

The function defining dollar volume of sales for receiving tubes and its corresponding relationship to receiving tube DMS conditions will approximate that function and DMS relationship experienced for semiconductors and integrated circuits.

Chapter 2

METHODOLOGY

As stated in Chapter 1, the objective of this research effort was to determine if dollar volume of sales for electronic components and its corresponding relationship to DMS can be used as a predictor of DMS of electronic components. This chapter describes the data source, the data collection plan, the data configuration/analysis plan, and the hypothesis test and decision criteria used in conducting this research.

Data Source

Two data elements were required for accomplishment of this research. The first element was the annual total dollar volume of sales for receiving tubes, semiconductors and integrated circuits. Data were accumulated for the entire population of these components manufactured in the United States. Historical dollar volume of sales data was collected to enable description of the evolutionary trend in the dollar volume sales for each component under study.

Dollar volume of sales data was extracted from marketing and financial publications contained in the Air Force Institute of Technology and the DESC Operations

Research Division libraries. Electronic component market data were also obtained from the Marketing Services Department, Electronic Industries Association.

Diminishing manufacturing source experiences involving receiving tubes, semiconductors and integrated circuits constitute the second data element required for this research. As the DESC is the single Defense Logistics Agency (DLA) manager for electronic components, the DMS data available from the DESC were considered a census of the entire population of DMS experienced in the DOD, for the components under study.

Data Collection Plan

The annual dollar volume of sales data were extracted from various governmental publications, such as the Bureau of Labor Statistics' Census of Manufactures, and from the Electronic Industry Association's Electronic Market Data Book. The sales data were collected by referencing the Standard Industrial Code (SIC) for each of the three components. The sales data for each component were assumed to be reliable based upon their inclusion in these recognized, authoritative reference materials.

DMS data were extracted from records available at the DESC. Additionally, interviews with personnel employed at the DESC who have been closely associated with definition, detection, and management of DMS were an additional source of DMS data.

Data Adjustment

Dollar sales values were adjusted to reflect a constant year value to allow for inflationary and deflationary fluctuations in the economy by use of the Wholesale Price Index (WPI) numbers, as published by the U.S. Bureau of Census. WPIs are constructed to measure changes which have occurred in the prices of selected commodities or groups of commodities with respect to the supply of money in the economy (7:118). Although prices may be weighted by quantities in order to give recognition to the relative importance of the commodities, the indexes are computed in such a way that changes in the index reflect changes in prices rather than changes in quantities (19).

Hypothesis Test and Decision Criteria

The research hypothesis has its foundation in two premises. The first is that the dollar volume growth curves for the three stated electronic components are similar. The second premise is that DMS occurs at the same position relative to a point on the growth curve for each respective component.

Testing the first premise required a determination of the function describing the growth curves for receiving tubes, semiconductors, and integrated circuits. Determination and comparison of the functions were accomplished using a curve fitting computer program (see Appendix C).

The CURFIT program package internally computes, and then prints, in association with each function, a corresponding index of determination. The index of determination, or coefficient of determination (R^2), is a measure of the efficiency of the least squares fit of the variable Y (dollar volume of sales) on the variable X (time). The R^2 value provides a measure of how well the growth curves produced by the electronic component data is approximated by each of the model functions contained in the CURFIT program package.

The goodness of fit of the curve produced, by the input data to the six functions represented in the CURFIT program, can be measured by the magnitude of the index of determination.

The higher the index of determination the more the variation from actual relationship is explained by the variables entered into the function. Or another way, the higher the index of determination, the closer the CURFIT equation matches the actual curve produced by the input data. The equation exhibiting the highest index of determination is, therefore, the equation of the six candidates, that best describes the actual relationship between the variables. If the functions defined for semiconductors and integrated circuits closely approximated the function describing dollar volume of sales for receiving tubes, and their associated R^2s were sufficiently high[1], the first premise was supported and the second premise investigated. The three components' functions were considered similar if there were no statistically significant differences among R^2s across the same function for all components. If, however, it had been found that the functions defining the dollar volume growth trends for the electronic components were dissimilar, or their R^2 were not sufficiently high[2], the first premise would have been considered insupportable and the hypothesis rejected.

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[1]For this type of research an R^2 value above .80 is usually considered acceptable (8:19; 15:412). For this study, an R^2 value of .90 was arbitrarily selected as the minimum, sufficiently high limit to insure a conservative treatment of the data.

[2]Ibid.

A visual indication of the dollar sales growth curve was first ascertained by graphing the data accumulated for receiving tubes (see Appendix H). The growth trend curve for tubes was depicted with dollar volume of sales (on the Y axis) over the time period in years (on the X axis). This graph provided a visual indication of growth. The Honeywell Computer CREATE program package CURFIT (see Appendix C) was used to determine the mathematical function most closely describing the curve from a selection of six available functions.

Dollar volume of sales data for semiconductors and integrated circuits were then graphed (see Appendix I, J) and evaluated using the CURFIT package and criteria previously established. Once the first premise was supported, the second premise was addressed. DMS data were analyzed to determine the initial occurrence of DMS for receiving tubes. The time of this occurrence was annotated relative to the peak dollar volume of sales for receiving tubes. Testing the second premise of the research hypothesis was accomplished by transferring the point of the initial DMS experience for tubes to the same relative point of the curve of dollar volume sales for semiconductors. This point was annotated as the predicted point of DMS experience for semiconductors. Actual DMS data for semiconductors were then compared. If the predicted DMS occurrence fell within an envelope of time determined sufficient[3] to enable evaluation of supply alternatives by the DESC, the premise was considered valid.

The initial occurrence of DMS for integrated circuits was then predicted and verified with actual data in a like manner as for semiconductors. The premise was accepted if the date of predicted DMS experience and actual DMS experience fell within the specified time envelope.

The hypothesis would have been accepted as a whole, given successful support of the two premises.

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[3]"Sufficient" time was defined to be a period of approximately one year (18). This time period is required to evaluate the particular DMS item, to determine user requirements, and to evaluate the alternatives available to the DESC (see Appendix B).

Chapter 3

DATA TREATMENT AND FINDINGS

This chapter addresses accumulation of the research data as well as adjustments in the data necessary to facilitate testing of the research hypothesis. Findings based on tests of the two underlying premises described in Chapter 2, are fully detailed.

Dollar Volume of Sales Data Collection

Dollar volume of sales data for the three electronic components were extracted from the 1977 Electronic Industries Association's (EIA) Electronic Market Data Book. This annual publication contains detailed information on production, sales, foreign trade, research and development, and government markets. Currently, over 500 companies voluntarily report confidential production and sales data to the EIA on a regular basis, thus providing the statistical basis for the reports contained in the Data Book (5:1).

The U.S. Bureau of Labor Statistics', Census of Manufactures was surveyed to verify accuracy and support the data contained in the EIA reports. The data from the Census of Manufactures were extracted by Standard Industrial Code (SIC) for the electronic components under consideration as follows (28:115):

Standard Industrial Code	Component
36710	Electron Tube, Receiving
36741	Integrated Circuits
36740 36742 36743 36749	Semiconductors

A comparison of the data from the government reports with the data available from the EIA indicated that the information contained in the EIA Data Book was appropriate for analysis. The information contained in the EIA Electronic Market Data Book was not identified by SIC, however, a verbal description of the components included in each category was provided. Data for each of the components under study were consolidated and tabulated. Data, together with consolidation and tabulation methods, appear in Appendices D, E, and F.

Application of the Wholesale Price Index (WPI)

As addressed in Chapter 2 under the section titled, Data Adjustment, it was necessary to adjust the dollar sales amounts by means of the WPI in order to indicate more accurate growth trends. The base year of 1967 was used as a matter of convenience as 1967 is the base year currently used by the U.S. Bureau of the Census. Use of the base year allowed data presented in individual year values to be adjusted so as to present the data in values related to the 1967 economic standard.

The index numbers used in this research were extracted from several editions of the U.S. Bureau of the Census' Statistical Abstract of the United States as no single edition covers the time frame under consideration. Several steps were taken to align all of the data to the 1967 base (see Appendix G). The WPIs from 1939 through 1947 were first obtained from the U.S. Bureau of the Census Volume titled: Statistical Abstract of the United States: Colonial Times to 1957. As electrical equipment during this time period was not reported as an entity, the category "All Commodities" was used. The WPIs for the "All Commodities" group were based on the year 1926.

The WPIs for the years 1947 through 1952 were selected from the 1953 edition. Electrical items were categorized separately under the major category of "Machinery and Motive Products" as "Electrical Machinery and Equipment." The base year in this edition was 1947.

The WPIs for 1953 through 1956 were from the 1957 edition. Years 1957 through 1961 were extracted from the 1962 edition. Both year groups were based on 1947 and were under the same category as the 1947 through 1952 year groups. The base year was changed to 1957, for the 1957 through 1962 WPIs, although the categories remained the same. These index numbers were extracted from the 1963 edition.

In the 1968 edition, from which the year group 1963 through 1967 data were extracted, the major category heading was changed to "Machinery and Equipment". The final year group, 1968 through 1975, index numbers were based on a base year 1967 and were extracted from the 1975 edition.

As the entire composite of index numbers was based on four different years, it was necessary to convert the 1926, 1947, and 1957 based index numbers to 1967 based numbers. As 1967 had a 1957 based index number and a 1967 based index number, a ratio was established by which the index numbers for 1957 through 1967 could be converted from a 1957 base to a 1967 base. A similar ratio was established from the overlap of the 1947 based index and the 1957 based index for the year 1957, and from the overlap of the 1926 based index and the 1947 based index of 1947. The 1967 based index numbers were then applied to the dollar volume of sales data.

Application of Curve Fitting and Premise One Validation

Once the dollar volume of sales data were adjusted to a single base year, determination of the individual functions identifying the dollar volume of sales growth curve for each of the three components was necessary to enable comparisons. The growth curve was defined as the dollar volume of sales up to the peak year of sales for the component. Sales subsequent to the peak year were not considered contributory to the growth of sales for the components. The data for the electronic components in question were graphed with the X axis representing year of sales and the Y axis representing the dollar volume of sales. In an effort to compensate for the range in the data values and to render the data more manageable, the dollar volume of sales values were converted to logarithmic form. The logarithmic dollar volume of sales values were then plotted against the respective years. The peak year of sales for each component was visually determined from the graph (see Appendices H, I, and J).

Dollar volume of sales data for receiving tubes from 1940 to the peak year of 1957 (18 years) were used as input to the CURFIT program. The function of the growth curve which exhibited the highest index of determination (.967) was the linear equation. (See Appendix K for complete computer output display.)

Dollar volume of sales data from 1954 to the peak year of 1960 (seven years) were used as input to the CURFIT program for semiconductors. Because the peak in dollar volume of sales for semiconductors was reached in approximately one-half of the time period experienced for receiving tubes, the time interval over which the data were plotted (X axis) was expanded by a factor of two to enable direct comparisons. The dollar volume of sales per year (Y axis) was not changed. The function for the growth curve for semiconductors which exhibited the highest index of determination was the linear equation (.959) (see Appendix L).

Dollar volume of sales data for integrated circuits from 1961 to 1975 (15 years) were used as input to CURFIT. Because integrated circuits experienced a similar growth trend as semiconductors and in the same time frame, the time interval over which the integrated circuit data were plotted, was also expanded by a factor of two to be consistent and to enable comparisons. Sales of integrated circuits has not peaked, therefore, all of the data currently available were used in the analysis. The index of determination produced by the CURFIT program was .945 for the linear equation (see Appendix M).

Based upon results produced by the CURFIT program, the functions defining the growth curves for receiving tubes, semiconductors, and integrated circuits were each determined to be linear as identified by the basic equation $Y = A + (B * X)$. The high index of determination for the linear function (above .90) exceeded the criteria established in each instance. Additionally, a Scheffe test on the R^2 values indicated no statistically significant difference among R^2s across the same function for all components; therefore, the first premise was accepted.

DMS Data Collection

Because DMS as a recognized, persistent business phenomenon in the electronic industry is relatively new, there is little formal documentation available pertaining to specific instances of DMS. At DESC the only available documentation consisted of a listing of buy-outs developed by the Supply Operations Division. This listing (dated 24 January 1978) contained data relating to buy-outs made since 1974 (30). DMS data predating 1974 relating to the components under study were obtained through interviews with personnel at the DESC who have been involved with the study and evaluation of DMS as members of a DMS Study Group (4; 18; 30).

Data Integration and Premise Two Validation

Validation of premise two required integration of the dollar volume of sales data and DMS data. The year DMS was experienced for receiving tubes was plotted relative to the dollar volume of sales growth curve for receiving tubes (see Appendix N). The first instance of DMS for receiving tubes of any magnitude detected by the DESC occurred in 1970, with the closing of the Wagner Electric electron tube plant (17). This DMS experience occurred 13 years subsequent to the peak year recorded for dollar volume of sales.

This 13 year time interval between the peak in dollar volume of sales and occurrence of DMS was then applied to the semiconductor data. Although electronic technology is advancing at an accelerating rate (13:43-44), determination of the financial structure of the electronic industry was beyond the scope of this research. As a conservative approach, the financial structure was assumed constant, enabling direct application of the interval between DMS and year of peak sales. The peak dollar volume of sales for semiconductors was 1960. Applying the 13 year time interval factor developed for receiving tubes to the semiconductor data, DMS was predicted to occur for semiconductors in 1973 (see Appendix O). Actual DMS experienced for semiconductors occurred in 1972, as a result of the production termination by Western Electric (4). The difference in the predicted versus actual occurrence was within the one year constraint criterion established in Chapter 2.

Because it could not be determined if dollar volume of sales for integrated circuits had reached a peak and the fact DMS for integrated circuits had already been documented in 1974 by the DESC (30) (see Appendix P), testing of premise two, incorporating integrated circuit data was not necessary. The occurrence of DMS prior to a peak in sales invalidated the premise.

Testing of the Hypothesis

The research hypothesis had as its foundation, two premises. The first, that the dollar volume of sales growth trends for the three electronic components was described by the same function, was tested as previously discussed. Based on the decision criteria, premise one was found supported. The second premise, that DMS occurs at the same relative position with respect to the growth curve for each component under study, could not be fully tested as dollar volume of sales data for integrated circuits provided no indication of a peak sales year, yet DMS for integrated circuits had been experienced by the DESC. This inability to test the second premise necessitated rejection of the second premise and, consequently, rejection of the hypothesis.

Chapter 4

RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter contains results based on tests of the research hypothesis. These are presented with conclusions pertaining to this research effort. Recommendations pertaining to further research are also presented.

Hypothesis Validation

The hypothesis tested in this research effort was a composite of two premises, both of which must have been supported for the hypothesis to have been accepted. Premise one specified that the function defining dollar volume of sales for receiving tubes approximates the functions defining the dollar volume of sales for semiconductors and for integrated circuits. Premise two specified that, given validation of premise one, DMS experienced for semiconductors and integrated circuits would occur within the same relative time interval with respect to peak dollar volume of sales as for receiving tubes.

Premise one was subjected to test by application of the curve fitting computer program CURFIT as detailed in Chapter 3. Premise two was tested by first determining the number of years between initial occurrence of DMS for receiving tubes with respect to the peak dollar volume of sales and then predicting an occurrence of DMS in semiconductors in the time interval from peak dollar volume of sales to DMS experience as recorded for receiving tubes. The predicted DMS for semiconductors was then compared with actual DMS experience for this component as recorded by the DESC. Integrated circuit data were to be treated in the same manner as semiconductor data.

Results

Test of premise one confirmed that the growth curves for dollar volume of sales for the selected electronic components followed the same function. The linear function [Y = A + (X * B)][1] was representative of the growth curves established for each component. The linear function displayed the highest index of determination for each component evaluated. These indices of determination (rounded to three decimal places) were .967, .959, and .945 for receiving tubes, semiconductors and integrated circuits, respectively (see Appendices K, L, and M). This commonality, as well as high index of determination for

---

[1]The dependent variable, Y, represented the logarithmic value of the dollar volume of sales. This variable was expressed in constant 1967 dollars, for the respective year represented by the independent variable X. A and B were the constant and slope of the function.

each component, was considered significant in as much as it validated a relationship among the growth curves. Validation of premise one allowed for the follow-on test of premise two.

Test of premise two confirmed that DMS for semiconductors occurred in the same time interval relative to peak dollar volume of sales as did DMS experienced for receiving tubes. Validation of premise two was impossible, however, as application of the test to integrated circuit data could be accomplished. A peak in dollar volume of sales for integrated circuit data was not discernible as the growth of sales has not peaked, however, a DMS condition in integrated circuits has already been experienced by the DESC. Occurrence of DMS prior to a peak year in dollar volume of sales invalidates premise two and is the basis for rejection of the research hypothesis.

Conclusions

The relationship between dollar volume of sales and DMS is not constant for the components under study. Because of this fact the authors are persuaded that the dollar volume of sales--DMS relationship experienced for one technology (receiving tubes) cannot be transferred to another related technology (integrated circuits) for purposes of predicting electrical component DMS conditions.

Based on the knowledge gained in this research effort, an awareness of the similarity among functions defining dollar volume of sales for given electronic components is beneficial, but this knowledge must be supplemented with additional data if it is to be of use in predicting DMS. These additional data may require that the function relating to the dollar volume of sales be integrated with a function relating to the element of time. It is apparent (though not conclusive from the data) that the life cycle of electronic technology is rapidly decreasing as new technology advances at an accelerating rate. It is the authors' opinion that there are some underlying economic relationships, perhaps associated with the dollar volume of sales and the linear functions detected in this research, which can be used to develop a sufficiently accurate method of predicting DMS as to be of benefit to the DESC.

Recommendations for Further Research

The problems of DMS experienced by the DESC, and the amount of dollars expended by DOD unnecessarily because of the lack of an accurate method for predicting DMS, demand that an acceptable solution be found. To this end, the following recommendations are made.

Expert opinion holds that DMS is basically an economic phenomenon. If a financial analysis is made of manufacturers on an individual basis, it may be found that there is some relationship of costs and profits in the production of electronic components that is common to all manufacturers. A model which describes the growth, decline, and eventual production termination of certain items can perhaps be developed based on this relationship. This model could then be used to predict DMS by inserting current financial elements as variables and then comparing actual experience with model results. A major obstacle in this approach is the unwillingness of manufacturers to release proprietary cost/profit figures.

As with any attempt to describe reality by means of a model, there are multiple variables which must be considered in addition to dollar volume of sales as employed in this research. A determination of the more significant variables is, therefore, necessary before an accurate model can be developed. The first step in this development is the identification of a conceptual model. Such factors as governmental regulation, cost per unit, and intensity of demand, although not tested, could be included in the conceptual model.

Yet another approach would be to use a different dependent variable such as cost per unit in lieu of dollar volume of sales. This approach, in conjunction with some method other than the CURFIT computer program, should be used both to verify the validity of dollar volume of sales as a variable and also to identify other variables.

The authors see the need for creation of an end item application computer file for electronic components according to national stock number (NSN). Procedures for maintaining current information in the file and for eliminating outdated NSNs would be required. The file would also include a forecast, by year, of the future demand on each end item and a current estimate of when each component or system would be phased out of the active inventory. The end item file would allow for a more accurate estimate of future requirements upon notification from a supplier that production of an item will be discontinued. The file would serve to reduce the "sufficient" time required to respond to a DMS situation.

The creation of an end item application file should be supplemented by an increased awareness within the DOD of the economics of electronic technology. It has been noted that the problems of DMS are economic in nature. Given the causes of the problem, the DOD should actively pursue a policy that is compatible with the economics of the electronics industry. Use of the standardized electronic component module for example would allow the DESC and DOD to capitalize on the commercial production base. As the DOD's share of market power continues to decline, DOD must rely on the commercial market for the direction of electronic technology. The acquisition cycle of major systems will continue to exceed the life cycle of electronic technology and result in obsolete equipment entering the inventory. To keep pace with the electronic life cycle, updating by module components should be stressed as opposed to modifying complete weapon systems.

Fully implementing the use of the end item--component file would be a tremendous task and would consume several years and a great deal of interservice/interagency coordination. It is the authors' opinion that such a program would return many times its implementation costs. Conversion to standardized components would further boost dollar savings by allowing a complete and accurate evaluation and prediction of future needs thereby eliminating, or, at least, reducing the amount of money spent unnecessarily in large buy-outs. More importantly, it would reduce the possibility of a compromise of national security threatened by an absence of repair parts caused by DMS, or an inadequate response to DMS, by the DESC.

The alternative to positive action in DMS is to witness an ever diminishing base for supply support. The DMS impact of the next few years may result in no supply support beyond current system production, other than that inventory purchased at considerable cost during initial provisioning. The authors wish to recognize the need for, and solicit active support for, the DESC in discovering a solution to the growing problem of DMS. We recommend the Air Force Institute of Technology encourage continued research in this area as an answer to DMS is urgently needed.

APPENDIX A

DEFINITIONS

APPENDIX A

Receiving Tube--An electron tube evacuated to such a degree that its electrical characteristics are essentially unaffected by the presence of any residual gas or vapor. There are hundreds of types of vacuum tubes which are classified according to type: receiving tubes, transmitting tubes, cathode-ray tubes, and microwave tubes are examples (10:276).

Semiconductor--A solid crystalline material whose electrical conductivity is intermediate between that of a metal and an insulator. Semiconductor devices called transistors exhibit amplification properties and are rapidly replacing vacuum tubes (11:212).

Integrated Circuits--Miniature electronic circuits produced within and upon a single semiconductor crystal. Integrated circuits have revolutionized electronics. Their low cost and high reliability have been essential in furthering the wide use of digital computers (12:187).

APPENDIX B

DESC ALTERNATIVES AND EVALUATIONS IN DMS SITUATIONS[1]

[1]These alternatives provided by Technical Services Division, DESC.

APPENDIX B

1. Buy-out,

2. Formalized agreement with vendor to use batch buys or develop groupings of products,

3. Have DCAS perform a survey of industry for capability of companies not currently in the business, but have the capability of becoming a supplier,

4. Substitution of devices to alleviate DMS situation,

5. Redesign the equipment,

6. Search for commercial alternate sources,

7. Establish government-owned,contractor-operated or government-owned, government-operated facilities,

8. Actually establish or set up a small business as a new supplier,

9. Use industrial preparedness program (IPP),

10. Examine foreign sources,

11. Research sources using the Thomas Register or the telephone,

12. Advertise in magazines or newspapers for sources,

13. Help establish alternate methods of processing in keeping with the current state-of-the-art.

APPENDIX C

THE HONEYWELL COMPUTER (CREATE) PROGRAM PACKAGE CURFIT

APPENDIX C

The Honeywell Computer (CREATE) program package CURFIT was used to determine the relationship between the two variables, dollar volume of sales and time, for the three electronic components under consideration. CURFIT uses the Method of Least Squares, a curve fitting technique, which computes an equation reflecting the relationship between two variables.

When a set of corresponding values of two variables are plotted on coordinate paper the function representing the general trend of the variables or, alternatively, the equation of the curve that passes through (or near) the points on the graph, so as to indicate their general trend, is called an empirical equation. The method of least squares is probably the most widely used method of obtaining empirical equations (14:1,55).

The CREATE program package CURFIT correlates the input variable data to one of the following six functions:

```
1.  Y = A + (B*X)
2.  Y = A * EXP(B*X)
3.  Y = A * (X * B)
4.  Y = A + (B/X)
5.  Y = 1/(A + B * X)
6.  Y = X/(A + B * X)
```

The following is a sample of a CURFIT program printout received at a time sharing remote terminal.

```
LIB CURFIT
READY
*100 DATA 6.618,7.007,7.524,8.138,8.310,8.562,8.752
*200 DATA 1,2,3,4,5,6,7
*RUN



PLEASE SPECIFY THE NUMBER OF VALUES (N) GIVEN AS DATA
FOR THE TWO INPUT VARIABLES, AND THE OUTPUT CODE (D).
(D=1 IF OUTPUT IS TO BE IN ORDER OF INCREASING VALUES
OF THE INDEPENDENT VARIABLE, ELSE D=0).  N,D = ?7,1

 L E A S T   S Q U A R E S   C U R V E   F I T

CURVE TYPE          INDEX  OF              A              B
                  DETERMINATION

1. Y=A+(B*X)         .9589391         6.373286        .3677856
2. Y=A*EXP(B*X)      .9474467         6.448326        .0478099
3. Y=A*(X^B)         .9725828         6.481579        .1528032
4. Y=A+(B/X)         .8198458         8.742061      -2.423361
5. Y=1/(A+B*X)       .9341313         .1537054      -.0062479
6. Y=X/(A+B*X)       .8634595         .0428056       .1128584


DETAILS FOR?1

    1. Y=A+(B*X)                 IS A LINEAR FUNCTION.  THE RESULTS
       (SORTED IN ORDER OF ASCENDING VALUES OF X)
       ARE AS FOLLOWS:

       X-ACTUAL       Y-ACTUAL       Y-CALC        PCT DIFFER

           1           6.618        6.741071      -1.8
           2           7.007        7.108857      -1.4
           3           7.524        7.476643                 .6
           4           8.138        7.844428                3.7
           5            8.31        8.212214                1.1
           6           8.562            8.58       -.2
           7           8.752        8.947785      -2.1
```

APPENDIX D

RECEIVING TUBES: DOLLAR VOLUME OF SALES

APPENDIX D

Year	Dollar Volume	Index Number	Log Form
1939	27,985	31.5	6.945
1940	27,610	32.1	6.948
1941	47,500	35.7	7.230
1942	43,000	40.4	7.240
1943	51,000	42.1	7.332
1944	62,140	42.5	7.442
1945	68,500	43.2	7.471
1946	101,000	49.5	7.699
1947	107,000	62.0	7.822
1948	112,000	65.0	7.862
1949	119,000	66.6	7.899
1950	250,000	68.7	8.235
1951	261,000	78.7	8.313
1952	259,116	77.6	8.303
1953	303,675	79.8	8.384
1954	275,999	81.4	8.352
1955	358,110	82.7	8.472
1956	374,186	89.3	8.524
1957	384,402	96.1	8.568
1958	341,929	98.2	8.526
1959	368,872	99.6	8.565
1960	331,742	99.5	8.519
1961	311,098	98.2	8.485
1962	301,525	96.7	8.465
1963	297,000	95.7	8.454
1964	272,000	95.1	8.413
1965	282,000	95.1	8.428
1966	301,000	97.2	8.466
1967	210,000	100.0	8.322
1968	196,000	101.3	8.298
1969	283,691	102.9	8.465
1970	259,171	106.4	8.441
1971	261,386	109.5	8.457
1972	240,950	110.4	8.425
1973	204,244	112.4	8.361
1974	167,157	125.0	8.320
1975	152,215	139.5	8.327

Source:

Dollar volume of sales extracted from 1977 EIA Data Book, Table 54, (5:95).

APPENDIX E

SEMICONDUCTORS: DOLLAR VOLUME OF SALES

APPENDIX E

Year	Dollar Volume (in millions)	Index Number	Log Form
1954	5.1	81.4	6.618
1955	12.3	82.9	7.007
1956	37.4	89.3	7.523
1957	142.9	96.1	8.137
1958	208.1	98.2	8.310
1959	365.9	99.6	8.561
1960	568.9	99.5	8.752
1961	537.6	98.2	8.722
1962	535.9	96.7	8.714
1963	488.2	95.7	8.669
1964	628.5	95.1	8.776
1965	761.0	95.1	8.859
1966	913.7	97.2	8.948
1967	781.7	100.0	8.893
1968	753.9	101.3	8.882
1969	864.6	102.9	8.949
1970	739.8	106.4	8.896
1971	594.0	109.5	8.813
1972	794.6	110.4	8.943
1973	843.7	112.4	8.976
1974	509.2	125.0	8.803
1975	421.8	139.5	8.769

Sources:

Dollar volume of sales extracted from 1977 EIA Data Book (5). 1954-1956, Table 76; 1957-1958, Table 76, Table 78; 1959, Table 76, Table 78, Table 85; 1960-1975, Table 76, Table 78, Table 85, Table 82.

APPENDIX F

INTEGRATED CIRCUITS: DOLLAR VOLUME OF SALES

APPENDIX F

Year	Dollar Volume (in millions)	Index Number	Log Form
1961	5	98.2	6.691
1962	10	96.7	6.985
1963	20	95.7	7.281
1964	51	95.1	7.685
1965	94	95.1	7.951
1966	173	97.2	8.225
1967	273	100.0	8.436
1968	367	101.3	8.570
1969	498	102.9	8.709
1970	524	106.4	8.756
1971	534	109.5	8.767
1972	718	110.4	8.899
1973	1,724	112.4	8.287
1974	2,122	125.0	9.423
1975	1,516	139.5	9.325

Source:

Dollar Volume of Sales extracted from 1977 EIA Data Book, Table 53 (5:93).

APPENDIX G

WHOLESALE PRICE INDEX NUMBERS

APPENDIX G

Year	1926 Base	1947 Base	1957 Base	1967 Base
1939	77.1			31.5
1940	78.6			32.1
1941	87.3			35.7
1942	98.8			40.4
1943	103.1			42.1
1944	104.0			42.5
1945	105.8			43.2
1946	121.1			49.5
1947	151.8	96.1		62.0
1948		100.7		65.0
1949		103.2		66.6
1950		106.4		68.7
1951		121.9		78.7
1952		120.3		77.6
1953		123.7		79.8
1954		126.2		81.4
1955		128.2		82.7
1956		138.4		89.3
1957		149.0	98.1	96.1
1958		152.2	100.2	98.2
1959		154.4	101.7	99.6
1960		154.2	101.3	99.5
1961		151.8	100.0	98.2
1962			98.4	96.7
1963			97.4	95.7
1964			96.8	95.1
1965			96.8	95.1
1966			99.0	97.2
1967			101.8	100.0
1968				101.3
1969				102.9
1970				106.4
1971				109.5
1972				110.4
1973				112.4
1974				125.0
1975				139.5

Sources:

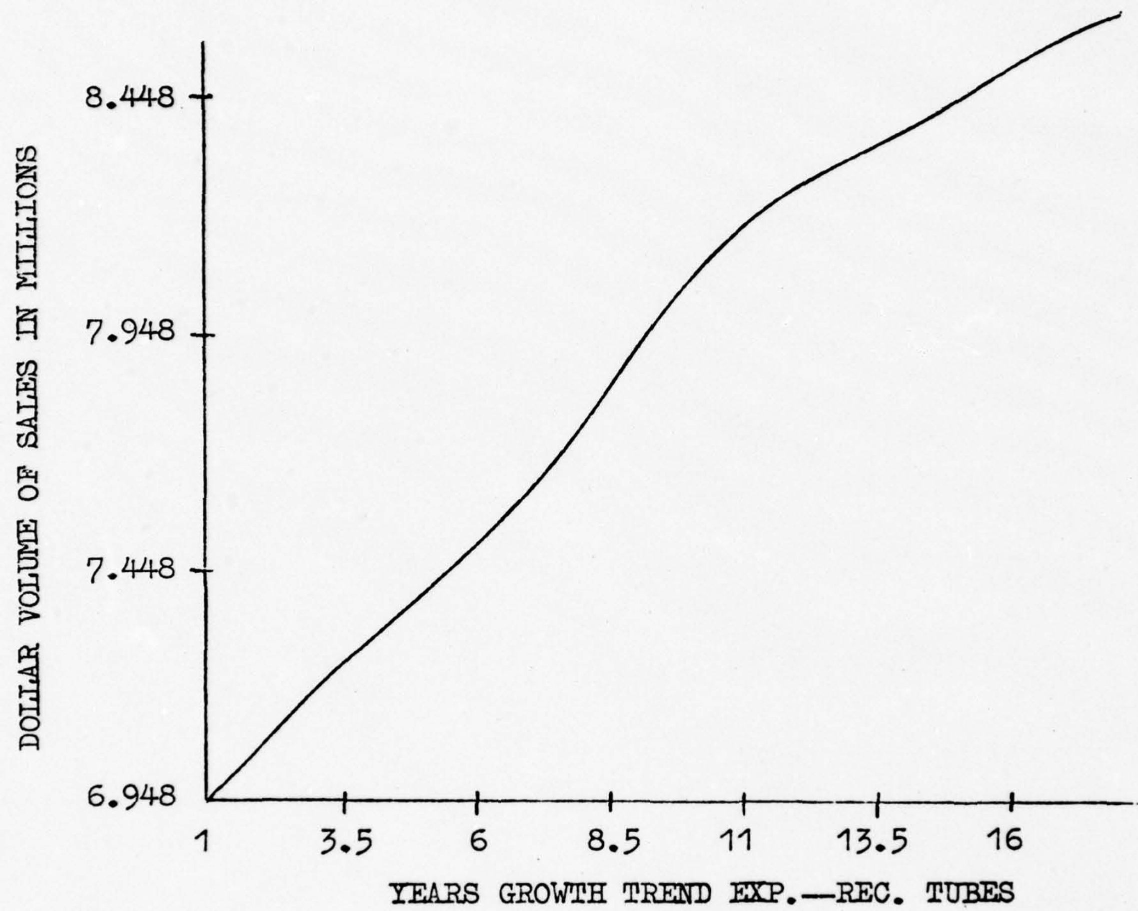
The index numbers were extracted from a number of editions of the U.S. Bureau of Census' Statistical Abstract

APPENDIX H

RECEIVING TUBE GROWTH CURVE GRAPH*

*From 1940 to year of peak sales (1957)

APPENDIX H*



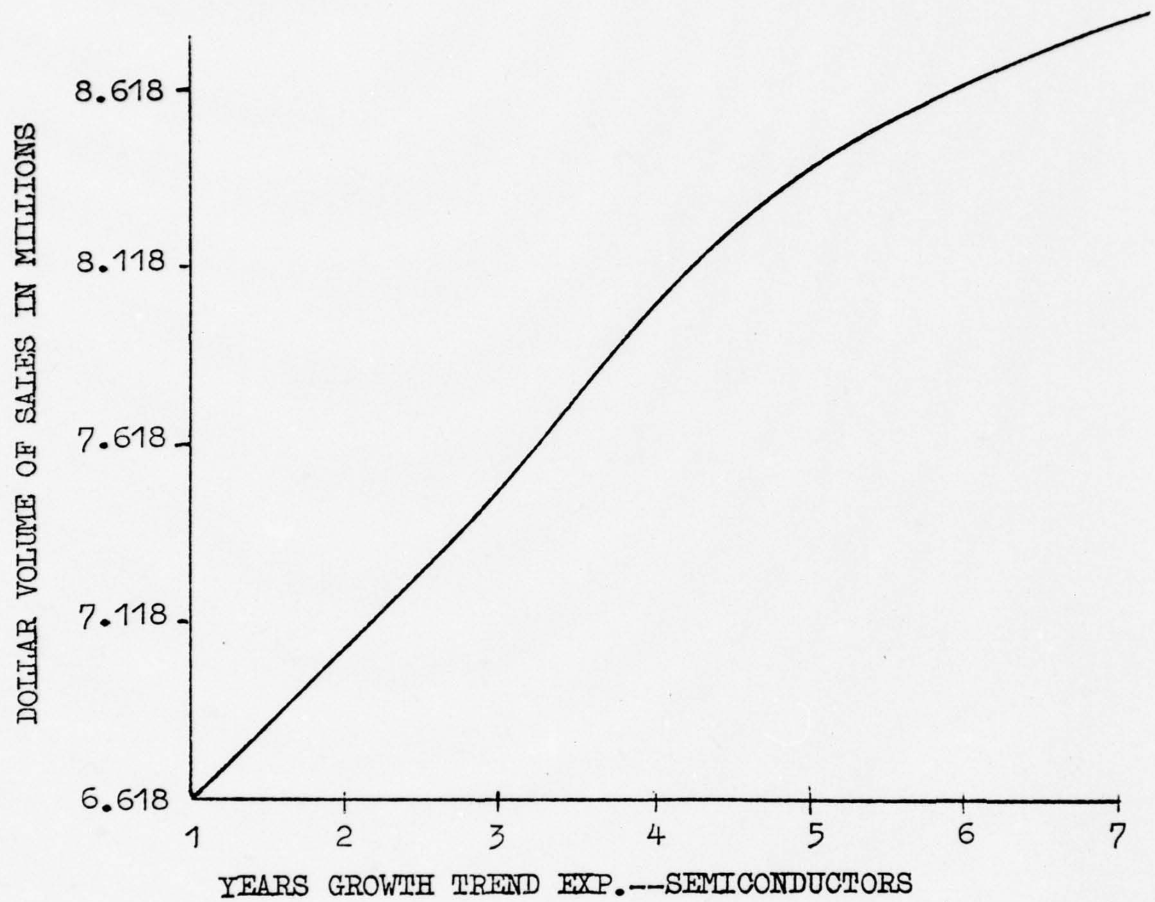
*Dollar volume of sales data in logarithmic form. Year 1 = 1940

APPENDIX I

SEMICONDUCTOR GROWTH CURVE GRAPH*

*From 1954 to year of peak sales (1960)

APPENDIX I*



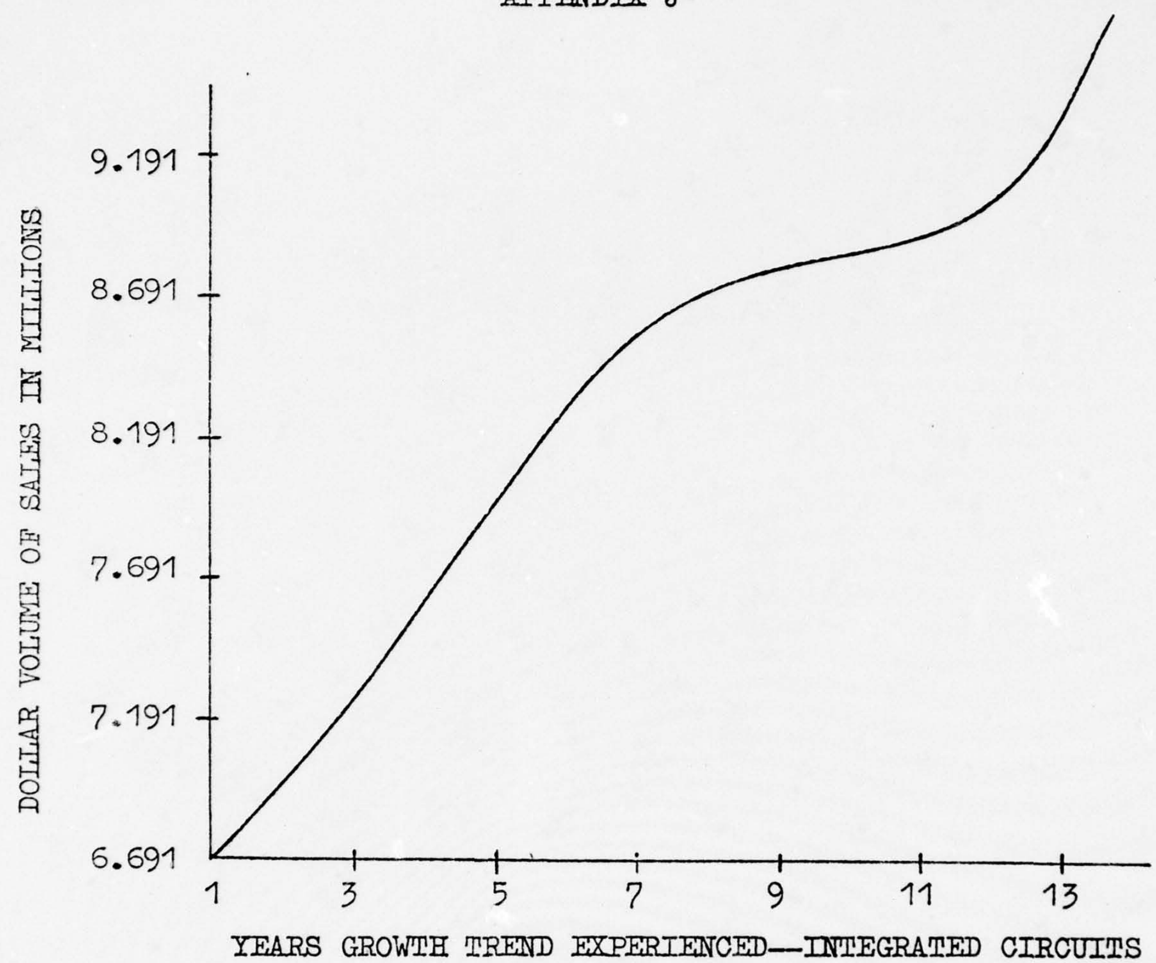
*Dollar volume of sales data in logarithmic form. Year 1 = 1954

APPENDIX J

INTEGRATED CIRCUIT GROWTH CURVE GRAPH*

*From 1961 to 1975

APPENDIX J*



*Dollar volume of sales data in logarithmic form. Year 1 = 1961.

APPENDIX K

CURFIT PROGRAM COMPUTER OUTPUT--RECEIVING TUBES

RECEIVING TUBE DATA


```
LIB CURFIT
READY
*100 DATA 6.948,7.230,7.240,7.332,7.422,7.471,7.669,7.822,7.862
*102 DATA 7.399,8.235,8.313,8.303,8.383,8.352,8.472,8.524,8.568
*200 DATA 1,2,3,4.5,6,7,8,9,10,11,12,13,14,15,16,17,18
*RUN

PLEASE SPECIFY THE NUMBER OF VALUES (N) GIVEN AS DATA
FOR THE TWO INPUT VARIABLES, AND THE OUTPUT CODE (D).
(D=1 IF OUTPUT IS TO BE IN ORDER OF INCREASING VALUES
OF THE INDEPENDENT VARIABLE, ELSE D=0).  N,D = ?18,1
```

L E A S T   S Q U A R E S   C U R V E   F I T

CURVE TYPE	INDEX OF DETERMINATION	A	B
1. Y=A+(B*X)	.9668744	6.978104	.0961352
2. Y=A*EXP(B*X)	.9619953	7.007326	.0122863
3. Y=A*(X^B)	.9117908	6.70365	.0796371
4. Y=A+(B/X)	.5782595	8.224073	-1.713372
5. Y=1/(A+B*X)	.9559158	.1422089	-.0015739
6. Y=X/(A+B*X)	.6221461	.0292628	.1215745

DETAILS FOR?1

1. Y=A+(B*X)   IS A LINEAR FUNCTION. THE RESULTS
   (SORTED IN ORDER OF ASCENDING VALUES OF X)
   ARE AS FOLLOWS:

X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	6.948	7.074239	-1.7
2	7.23	7.170374	.8
3	7.24	7.26651	-.3
4	7.332	7.362645	-.4
5	7.422	7.45878	-.4
6	7.471	7.554915	-1.1
7	7.669	7.65105	.2
8	7.822	7.747186	.9
9	7.862	7.843321	.2
10	7.399	7.939456	-.5
11	8.235	8.035591	2.4
12	8.313	8.131727	2.2
13	8.303	8.227862	.9
14	8.383	8.323997	.7
15	8.352	8.420132	-.8
16	8.472	8.516267	-.5
17	8.524	8.612403	-1
18	8.568	8.708538	-1.6

APPENDIX L

CURFIT PROGRAM COMPUTER OUTPUT--SEMICONDUCTORS

SEMICONDUCTOR DATA

```
LIB CURFIT
READY
*100 DATA 6.618,7.007,7.524,8.138,8.310,8.562,8.753
*200 DATA 1,3,5,7,9,11,13
*RUN


PLEASE SPECIFY THE NUMBER OF VALUES (N) GIVEN AS DATA
FOR THE TWO INPUT VARIABLES, AND THE OUTPUT CODE (D).
(D=1 IF OUTPUT IS TO BE IN ORDER OF INCREASING VALUES
OF THE INDEPENDENT VARIABLE, ELSE D=0).  N,D = ?7,1


 L E A S T   S Q U A R E S   C U R V E   F I T

CURVE TYPE           INDEX OF              A                  B
                   DETERMINATION

1. Y=A+(B*X)          .9590573         6.556946          .1839464
2. Y=A*EXP(B*X)        .947564         6.604154          .0239111
3. Y=A*(X^B)          .9453706         6.426326          .1153471
4. Y=A+(B/X)          .6981807          8.41912         -2.057068
5. Y=1/(A+B*X)        .9342488         .1505345         -.0031246
6. Y=X/(A+B*X)        .7509177         .03367163          .118457


DETAILS FOR?1

    1. Y=A+(B*X)                    IS A LINEAR FUNCTION.  THE RESULTS
       (SORTED IN ORDER OF ASCENDING VALUES OF X)
       ARE AS FOLLOWS:

     X-ACTUAL            Y-ACTUAL      Y-CALC        PCT DIFFER

            1              6.618       6.740893      -1.8
            3              7.007       7.108786      -1.4
            5              7.524       7.476678                  .6
            7              8.138       7.844571                 3.7
            9               8.31       8.212464                 1.1
           11              8.562       8.580357       -.2
           13              8.753        8.94825      -2.1
```

APPENDIX M

CURFIT PROGRAM COMPUTER OUTPUT--INTEGRATED CIRCUITS

```
LIB CURFIT
READY
*100 DATA 6.691,6.985,7.282,7.686,7.951,8.226,8.436
*102 DATA 8.570,8.710,8.746,8.767,8.899,9.287,9.424
*200 DATA 1,3,5,7,9,11,13,15,17,19,21,23,25,27
*RUN
```

PLEASE SPECIFY THE NUMBER OF VALUES (N) GIVEN AS DATA FOR THE TWO INPUT VARIABLES, AND THE OUTPUT CODE (D). (D=1 IF OUTPUT IS TO BE IN ORDER OF INCREASING VALUES OF THE INDEPENDENT VARIABLE, ELSE D=0). N,D = ?14,1

L E A S T   S Q U A R E S   C U R V E   F I T

CURVE TYPE	INDEX OF DETERMINATION	A	B
1. Y=A+(B*X)	.9453764	6.899397	.0972879
2. Y=A*EXP(B*X)	.9269711	6.943172	.012061
3. Y=A*(X^B)	.945491	6.355995	.1091397
4. Y=A+(B/X)	.5724125	8.671625	-2.49534
5. Y=1/(A+B*X)	.9048175	.143361	-.0015054
6. Y=X/(A+B*X)	.6435891	.0418512	.115405

DETAILS FOR?1

1. Y=A+(B*X) IS A LINEAR FUNCTION. THE RESULTS (SORTED IN ORDER OF ASCENDING VALUES OF X) ARE AS FOLLOWS:

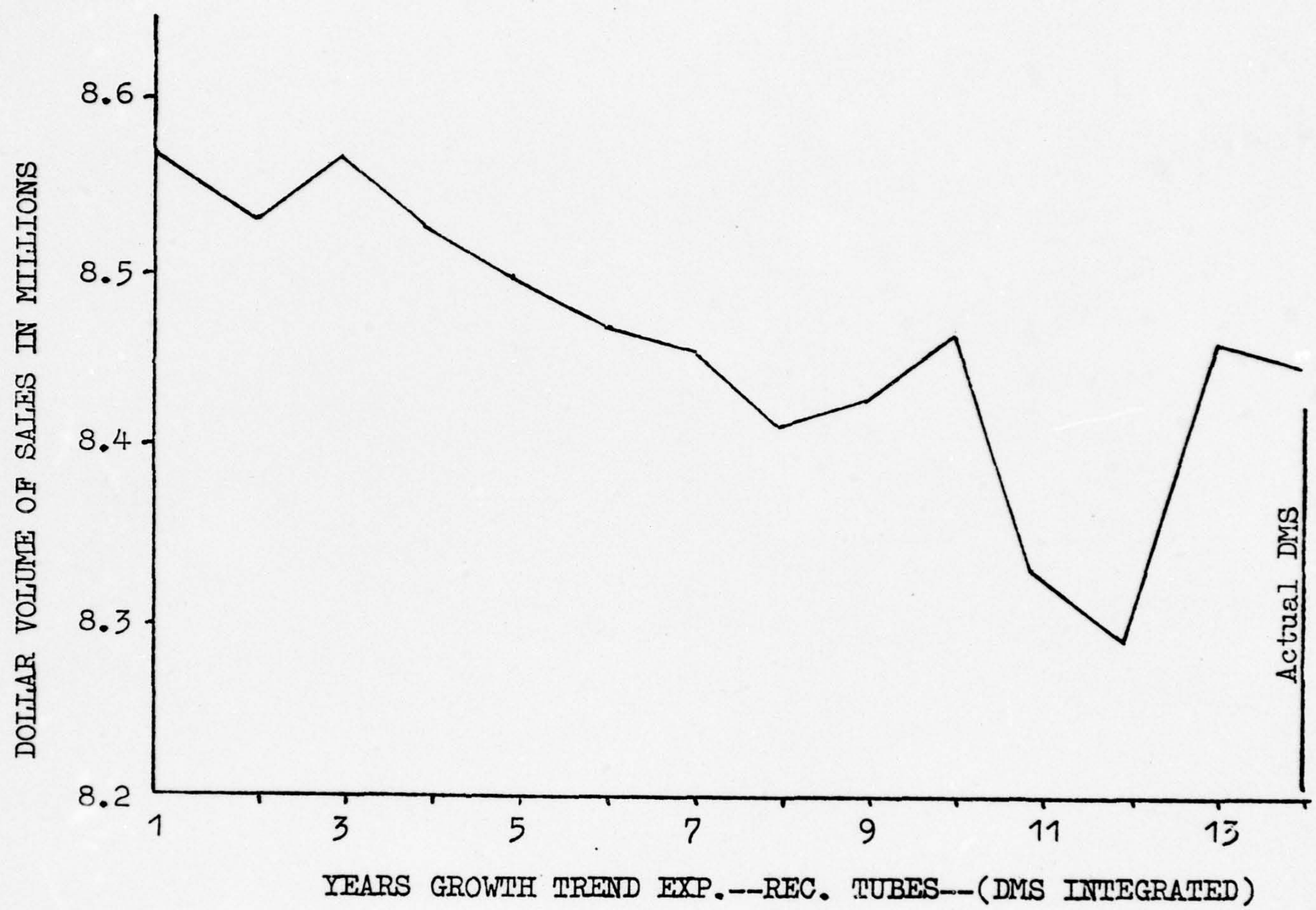
X-ACTUAL	Y-ACTUAL	Y-CALC	PCT DIFFER
1	6.691	6.996685	-4.3
3	6.985	7.191261	-2.8
5	7.282	7.385837	-1.4
7	7.686	7.580413	1.3
9	7.951	7.774989	2.2
11	8.226	7.969564	3.2
13	8.436	8.16414	3.3
15	8.57	8.358716	2.5
17	8.71	8.553292	1.8
19	8.746	8.747868	0
21	8.767	8.942443	-1.9
23	8.899	9.137019	-2.6
25	9.287	9.331595	-.4
27	9.424	9.526171	-1

APPENDIX N

RECEIVING TUBE GROWTH CURVE GRAPH WITH DMS PLOT*

*From peak year of sales (1957) to first recorded occurrence of DMS (1970)

APPENDIX N*



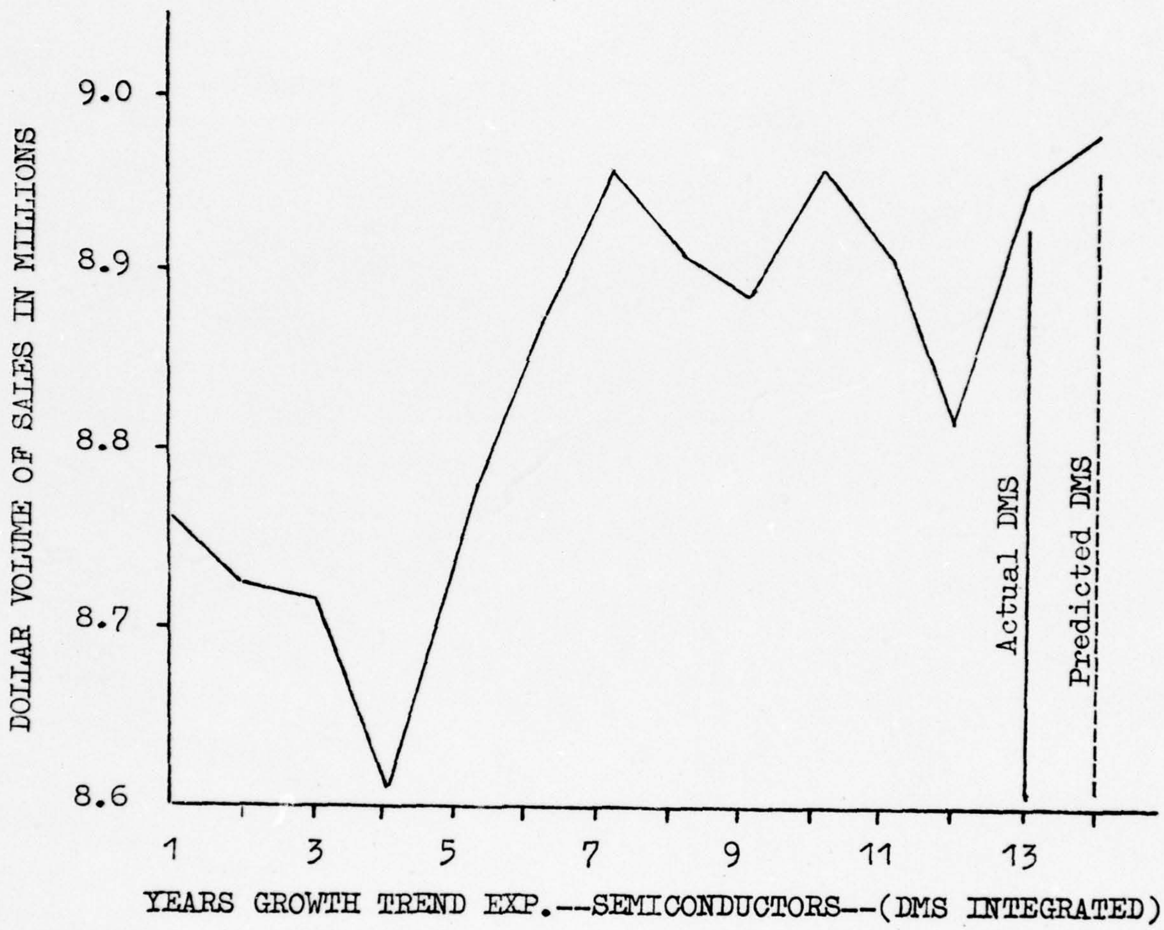
*Dollar volume of sales data in logarithmic form. Year 1 = 1957.

APPENDIX O

SEMICONDUCTOR GROWTH CURVE GRAPH WITH DMS PLOT*

*From peak year of sales (1960) to year of predicted DMS (1973)

APPENDIX O*



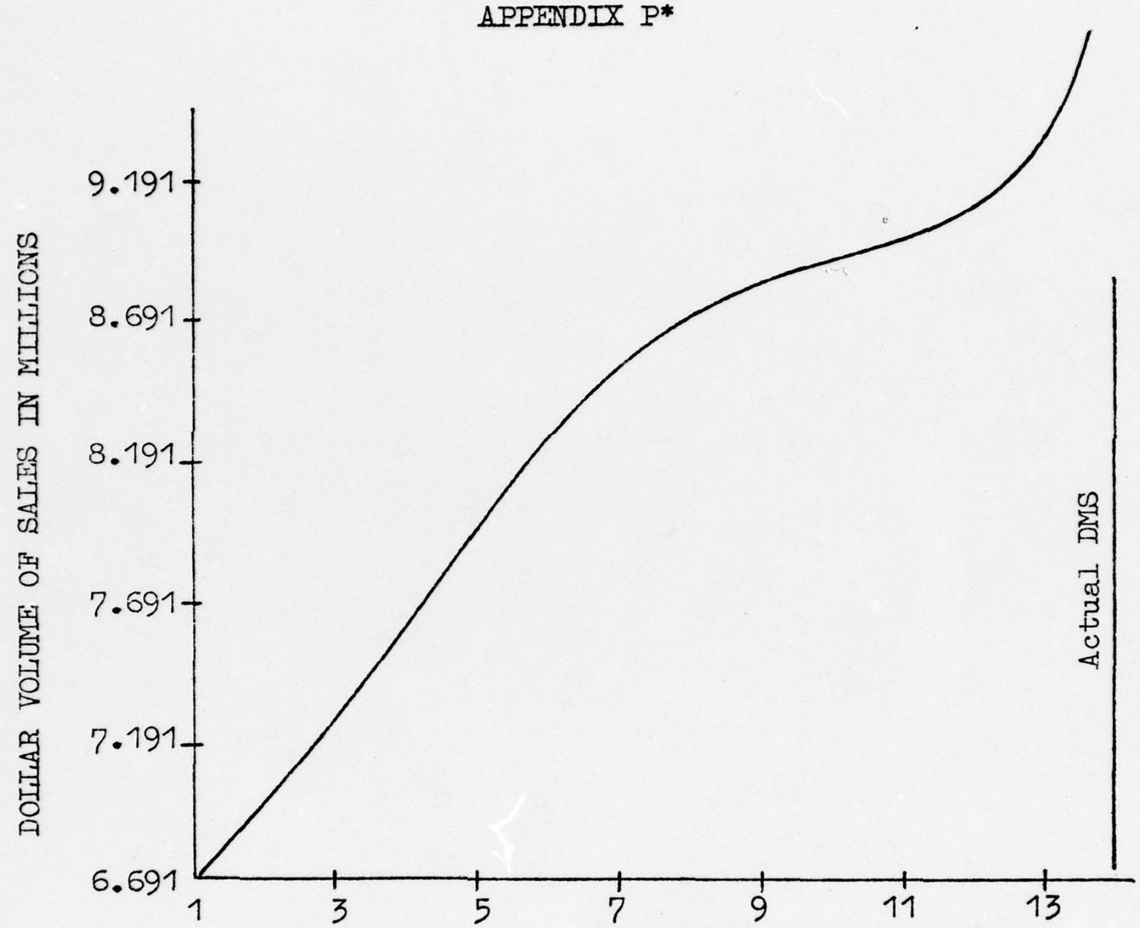
*Dollar volume of sales data in logarithmic form. Year 1 = 1960

APPENDIX P

INTEGRATED CIRCUIT GROWTH CURVE GRAPH WITH DMS PLOT*

*From 1961 to first recorded occurrence of DMS (1974)

APPENDIX P*



YEARS GROWTH TREND EXPERIENCED--INTEGRATED CIRCUITS--(DMS INTEGRATED)

*Dollar volume of sales data in logarithmic form. Year 1 = 1961.

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