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ECONOMIC INDICATORS
FOR THE UNITED STATES ALUMINUM INDUSTRY

by

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ABSTRACT

This thesis is a study of time series in the U.S. aluminum industry. The main purpose of this thesis is to find leading indexes of Aluminum Shipments and Aluminum Scrap Prices, respectively, so that the industry may be better prepared for situations in which uncertain patterns of fluctuations occur.

Various time series in the U.S. aluminum industry were collected for this research--some directly relevant to the aluminum industry and others indirectly connected. These time series were graphed and dated for turning points. These turning points of fluctuations were compared to those of Aluminum Shipments and Scrap Prices. Leading indicators of these two subject time series were sorted out from the time series. The Leading Indexes were formed from these leading indicators. Why these leading indicators lead the subject time series, such as Aluminum Shipments and Aluminum Scrap Prices, is explained. Sequential signal analysis and regression analysis methods were applied to measure performance of these Leading Indexes. These analyses showed Leading Indexes lead the subject time series successfully. The Leading Index of Aluminum Shipments, A5LD1, had eleven leads, and one exact

coincidency. The median of leads was two months. The Leading Index of Aluminum Scrap Prices, Y2LD1, had ten leads, one exact coincidency, and one lag. The median of leads was eight months. In the sequential signal analysis, the first signal of the recession and recovery of Aluminum Shipments lagged the turning points by three months on average. The first signal of peak of Aluminum Scrap Prices had a four-month lead on average, and the standard deviation of leads was eight months. The first signal of trough of Aluminum Scrap Prices had a four- month lead on average, and the standard deviation of leads was again eight months. In conclusion, the turning points of the two Leading Indexes generated for Aluminum Shipments and Aluminum Scrap Prices, respectively, mostly led those of the subject time series. Therefore, they can be used as Leading Indexes in an affirmative way, even though it is not statistically reliable to assume that they will lead the subject time series all the time.

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Chapter 1

INTRODUCTION

It is widely understood that the United States metal industry is influenced by the cyclical pattern of the ambient economy (Kaufmann 1983). The U.S. aluminum industry is experiencing cyclical fluctuations in shipments and prices of scrap and ingot because of fluctuations in demand, mainly from the construction and transportation sectors of the economy. When demand fluctuates, the production of primary and secondary ingots fluctuates. These fluctuations are believed to be closely related to those in the general economy. The aluminum industry is capital-intensive, and the demand for aluminum products is often postponable.

For most of the twentieth century, a small number of producers dominated the aluminum industry. The free world aluminum industry at one time was described as an oligopoly composed of six multinational firms. Fully integrated, these companies occupy strategic positions in the industry. They produce bauxite and alumina and also market both aluminum metal and end products. The overwhelming U.S. dominance of aluminum production through the Second World War has been reduced to a quarter of the world market share in 1983 (McCawley & Baumgardner 1985). Since World War II, two developments have changed the structure of the aluminum industry. One was the shift in the geographical distribution of available bauxite, and the other was the development of smelting facilities in Third World countries. These changes have resulted in an increase in the number of aluminum producers.

In this research Aluminum Shipments and Scrap Prices were chosen as subjects of forecasting because Aluminum Shipments is a good proxy of movement of the volume in the industry and Scrap Price is a good proxy of the price movement. Aluminum Ingot Production also represents the volume change. However, it turned out to a lagging indicator of Aluminum Shipments. In the case of various price series in the industry, most of the price series except Scrap Prices did not cover long time periods. There are three major prices in the primary aluminum ingot market: Producers' Price, Midwest Ingot Price, and LME Ingot Price. For a long time, the Producers' Price dominated the market. However, because of the expansion in the number of producers all over the world during the last 20 years, the market-controlling power of major companies has been reduced. The increase in competition has become a cause of price volatility. The market recognition of contract prices for aluminum ingot in the midwest market in the United States started in 1972. Since then it has served as an official entity for the quotation of free market prices of aluminum ingot in the United States. In 1978 the London Metal Exchange (LME) started the spot and forward contract of aluminum ingot. The LME contract for forward deals of aluminum ingot has served as a hedging mechanism for many segments of the aluminum industry. It has been found that the Midwest Price and the LME Price have showed similar fluctuations; i.e., coincident indicators. However, the LME Price has too short a history to be compared with other time series related to the aluminum industry. Some other prices in the aluminum industry include Cast Aluminum Scrap Price, Clipping Price of Scrap Aluminum, and Secondary Aluminum Price. In this study, the Cast Aluminum Scrap Price was found to be a coincident indicator of the Clipping Price of Scrap Aluminum. The Secondary Aluminum Price (No. 380) was not very cyclical until about 1974. Finally, the Cast Aluminum Scrap Price was selected as a subject of forecasting, owing to its cyclicality through the period of 1948-84 and its character as a leader among various price groups.

Several analytical methods have been in use to study the fluctuations in the level of the general economy. One of the methods is the cyclical indicator approach by which three categories of the indicators, such as leading indicators, coincident indicators, and lagging indicators are defined. The National Bureau of Economic Research has been the center for research on the general economy using this method. The Bureau of Economic Analysis is also involved with business cycle indicator research. It publishes Business Conditions Digest (BCD), a monthly magazine which contains graphs and data of main time series and composite indexes.

Research for this study on developing economic indicators in the aluminum industry started when Dr. Geoffrey H. Moore, director of the Center for International Business Cycle Research (CIBCR) at Columbia University, joined the team researching cyclical indicators of the mineral industry at Colorado School of Mines in 1984. The purpose here was to find leading indicators of shipments and prices in the aluminum industry, and to generate composite leading indexes. The method chosen was that used by CIBCR. Various time series in the aluminum industry and in related sectors such as the car industry and construction industry became the subject of analysis. Out of the time series that are relevant to the aluminum industry, several time series, such as Local Building

Permits and New Orders of Aluminum, were found to lead the Shipments and Scrap Prices. These leading indicators were put into the process of CIBCR to create two composite leading indexes. Each one of those composite leading indexes proved to be a good leading index for the subject time series.

Because the aluminum industry is cyclical and, therefore, risky, an early warning signal, i.e., composite leading index, would be useful in managing the firms in the industry and the suppliers, such as electrical utilities. Results of this study are meaningful in the sense that two main composite leading indexes were created for the first time in the U.S. aluminum industry: one for aluminum shipments, the other for cast aluminum scrap prices. Regression analysis and statistical tests were applied to the leading indexes and the subject time series, i.e., shipments and scrap prices to support the fruitfulness of the results. The sequential signal analysis was also done to find signals of peaks and troughs of the subject time series.

Chapter 2

U.S. BUSINESS CYCLE

2.1 Theory of Business Cycle

The term "business cycle" refers to the recurrent ups and downs in the level of economic activity which extend over a period of several years. In an idealized business cycle, the cycle arrives at the peak where the economy is at full employment and the national output is also at capacity, or very close to it. The price level is likely to rise during this cyclical phase. In the recession period, after peak output and employment both decline, prices in the economy tend to be inflexible in a downward direction. The price level is likely to fall only if the recession is severe and extended. The trough is where output and employment bottom out at their lowest levels. In the recovery period the economy's levels of output and employment expand toward full employment. As recovery strengthens, the price level may begin to rise prior to the realization of full employment and capacity production. Despite common phases, specific business cycles vary greatly in duration and intensity.

There are many types of economic fluctuations. Because of the complexity of economic phenomena, it may be that there are as many types of fluctuations or cycles as there are economic variables. Almost every aspect of economic life displays seasonal variations. As one extends the span of observation, one finds new kinds of fluctuations, such as the hog cycle and the wheat cycle, the inventory cycle, and the construction cycle.

Modern economic theory has recorded a number of periods of difficult times, often called depressions, during which the business economy is marked by sudden stock market declines, commercial bankruptcies, bank failures, and mounting unemployment. Such crises are considered as pathological incidents or catastrophies in economic life, rather than as a normal part of it.

2.1.1 Classification of Business Cycles

1. Juglar's Eight-Year Cycle. The first authority to explore economic cycles as periodically recurring phenomena may have been a French physician, Clement Juglar, in 1860 (Estey 1956, 112). Other writers who developed Juglar's approach suggested that the cycles repeat every nine or ten years, and discerned three phases, or periods, of a typical cycle: prosperity, crises, and liquidation. Subsequent analysis has tended to designate 1825, 1836, 1847, 1857, 1866, 1873, 1882, 1890, 1900, 1907, 1913, 1920, and 1929 as

initial years of crisis. In the years since 1929, the regularity of business fluctuations has been somewhat offset by government anticyclical policies.

2. Kondratieff's Waves. Longer cycles have also been studied. The construction industry in the United States has been found to have cycles of 17 to 18 years, and in England of 20 to 22 years. Finally, there are long waves, or so-called Kondratieff cycles, named for a Russian economist, Nikolai D. Kondratieff, who showed that in the major Western countries during the 150 years from 1790 to 1940 it was possible to distinguish three periods of slow expansions and contractions of economic activity averaging 50 years in length (Valentine 1982):

1792 - 1850	Expansion: 1792–1815	23 years
	Contraction: 1815–50	35 years
1850 - 1896	Expansion: 1850–73	23 years
	Contraction: 1873–96	23 years
1896 - 1940	Expansion: 1896–1920	24 years
	Contraction: 1920–40	20 years

Only those three Kondratieff waves have been observed.

Some students of business cycles have analyzed them by statistical methods, in the hope of finding regularities that are not immediately apparent. One speculative theory has held that the larger cycles were built up from smaller ones. Thus, two seasonal cycles would produce a two-year cycle, two of which would produce a four-year cycle; two four-year cycles would become an eight-year, or Juglar, cycle, and so on. The hypothesis is not widely accepted.

Cycles of different lengths are closely connected with economic growth. In nineteenth-century Germany, for example, upswings in total economic activity were associated with the growth of the railroad, metallurgy, textile, and building industries. Periodical crises brought slowdowns in growth. The crisis of 1873 led to a wave of financial and industrial bankruptcies; recovery started in 1877 when iron production ceased to fall, and by 1880 a new upswing was underway. The recession of 1882 was less severe than the previous one, but a slump that began in 1890 led to a serious depression, with complaints of overproduction.

The year 1890 was also one of financial crisis in England and the United States. English pig-iron production fell significantly and unemployment increased. The financial crisis was intense in the United States, where, in 1893, a stock market panic led to widespread bank failures.

The recession in 1900 was followed by an unusually vigorous upsurge in almost all of the Western economies. U.S. pig-iron production increased by more than 150 percent during the expansion, which lasted until 1907; building permits more than doubled; and freight traffic rose by more than 50 percent. Prices rose more and more rapidly as the U.S. economy approached full employment.

2.1.2 Explanations of the Cause of the Business Cycle

1. John Stuart Mills. John Mills read a paper before the Manchester Statistical Society in 1867 in which he made some crucial observations about the recurrence of the crises in 1815, 1825, 1836-39, 1847, 1857, and 1866. He suggested that the fluctuations are recurrent and may be as "inevitable as the periodical tempests which clear the atmosphere of tropical regions." He thought the principal cause was a recurrent change in the mental mood of the trading public. Outside forces might speed up or delay the shift in phases, but his emphasis was on a credit cycle (Bratt 1961).

2. Karl Marx. Marx linked the explanation of the business cycle to investment spending. He remarked that capitalists will invest more at some times than at others. When the army of unemployed grows and wages fall, capitalists will tend to hire more labor and invest less in

machinery and equipment. But when wages rise, capitalists will substitute machines for workers, bringing about unemployment and depressed wages. Marx argued that this situation causes periodic crises (Eklund & Hebert 1975, 187).

3. William Stanley Jevons. Jevons, an economist famous for his value theory, argued that periodic fluctuations were related to deficient or excessive harvests, saying that "great vintage years" recur every ten or eleven years. Later, when sunspot cycles were developed, he tried to relate the harvest fluctuation with the cycle in sunspots (Bratt 1961, 144).

4. A. C. Pigou. Pigou clearly understood the business cycle as a recurrent fluctuation, not as represented by isolated crises, a break with the classical position that fluctuations represent isolated phenomena. His position is indicated by a shift in psychological attitudes. His analysis was far reaching. It also recognized impulses generated by monetary and real factors. Monetary factors, in addition to interrelated influences with psychological factors, might arise from issues of paper money, gold production, or movements of international reserves. Real factors might set up impulses because of harvest variations, inventions, industrial disputes, changes in

taste or changes in foreign demand. Generally, the impulses tend to produce expansion or contraction through their effect on variations in expectations of profit. The impulses produce a business cycle because of conditions in the economy which predetermine responses. Some of these conditions are monetary and banking arrangements, the capitalistic nature of production (particularly derived demand and the replacement cycle), and other industrial conditions in foreign demand (Bratt 1961, 155). Generally, the impulses tend to produce expansion.

5. Schumpeter. Schumpeter argued that the economic development is propelled by innovation. He observed five basic types of innovation. They are 1) introduction of new goods, 2) introduction of a new method of production, 3) the opening of a new market, 4) the conquest of a new source of supply of raw materials, and 5) the reorganization of an industry (Schumpeter 1939, 87-102). There is a need for capital when an entrepreneur plans to implement new ideas. As others engage in the same activity, the aggregate investment can expand its size considerably. The expenditures of the innovators increase the revenues of producers of capital goods. The wages of the employees producing capital goods increase, which, in turn, increases consumption. The peak of the expansion is caused by the

failure of the innovators to continue to innovate. The demand for capital goods shrinks once the innovation has been implemented. The economy will try to get to the equilibrium after the innovation, which creates a recessionary period. The new cycle will start with another innovation (Schumpeter 1939).

6. John Maynard Keynes. In the Keynsian paradigm, the recession can be initiated by a drop in either investment or consumption expenditures. Because of the multiplier effect, the income level will fall farther than the decrease in expenditures that initiated the downward spiral. A drop in income may also have negative effects on other investment projects.

Since the aggregate income level declines during the recession, businesses may conclude that some scheduled investment projects are no longer wise and should be postponed or cancelled. This further reduction in investment brings about a greater reduction in national income than could be estimated by considering only the multiplying effect of the initial decrease in investment. Once the economy strikes the bottom, it may stay there for a while. However, new technological innovations, changes in consumer and business expectations, etc., can cause an increase in aggregate demand. Then the multiplier process will affect the economy in an upward direction. Once the economy flourishes, more and more investment projects will look profitable, and there can be an accumulative upward movement until the economy moves close to full employment of resources and the labor force. In this stage, businesses may become too optimistic and overproduce and overinvest. If excess capacity develops, firms will cut off their investment spending, setting the stage for the next recession (McKenzie 1978, 533–534).

7. Monetarists' view. Monetary theorists hold that cycles, as compared with other variations in economic activity, are brought about by the elasticity of bank credit. They argue that expansion and contraction of bank credit are not only a necessary accompaniment of similar variations in economic activity but are an efficient cause thereof. They hold, further, that this is not a necessary condition of banking, but that it has been brought about by the traditional practices of bankers. After all, according to the monetarists' explanation of the cycle, the known behavior of the cycle could not occur in the absence of an elastic money supply. The monetary supply of all countries with modern banking system is elastic, i.e., capable of expansion and contraction; such expansion and contraction, when they occur, lead to cumulative expansion

and contraction of industry and are sufficient to account for the business cycle, even if no other causes were present. The normal behavior of bankers is such as to cause them to bring about these contractions and expansions instead of controlling the monetary supply in the interests of stabilization. Therefore, the business cycle is essentially the result of variations in the money supply produced by the banking systems of advanced industrial communities (Estey 1956, 191-206).

8. Wesley Clair Mitchell. Mitchell's point was to show how fluctuations grow out of and grow into each other. Fundamentally, he explained, there are cumulative changes in the process of the business economy. To study them, Mitchell was determined to limit his assumptions and avoid the obstacle of a rigid theoretical framework. He thought that traditional theory was naively mechanical because it lacked institutional perspective. Bratt (1961, 151) observed that

> [a]ccording to Mitchell, reasonable theories multiplied abundantly since imaginative thinkers had no problem in assigning crucial role to one factor after another. . . . Occasionally a theorist would use statistical data, but as a rule their function, when called upon at all, was merely to support or illustrate a particular stage of an argument.

Mitchell later broke with this tradition.

To study cumulative changes, Mitchell analyzed leads and lags and regularity of sequences. He realized that a clue or organizing principle must be employed. For this purpose, he hit on profits, which surely represent an important part of the motivation in business transactions. This led him to place much emphasis on the relative movement of cost prices and selling prices. For these purposes, he examined commodity prices, wage rates, interest rates, and other monetary factors (Bratt 1961, 151).

For practical purposes, it is useful to know the typical shape of a cycle and how to recognize its peak and trough. A great amount of work has been done in what may be called the morphology of cycles. Arthur F. Burns and Wesley C. Mitchell have based such studies on the assumption that at any specific time there are as many cycles as there are forms of economic activity or variables to be studied and have tried to measure these in relation to a "reference cycle," which they artificially constructed as a standard of comparison. The object was to describe the shape of each specific cycle, to analyze its phases, to measure its duration and velocity, and to measure the amplitude or size of the cycle.

2.2 History of U.S. Business Cycle

The definition of business cycle that led to the construction of a widely accepted chronology of cycles in the United States was formulated by Wesley C. Mitchell in 1927. In 1946, Mitchell and Arthur F. Burns revised the definition in certain respects but left its major content intact. It has continued to be used by the National Bureau of Economic Research in establishing cycle peak and trough dates. The definition is as follows (Burns & Mitchell 1946, 3):

> Business cycles are a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similar general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodical; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own.

On the basis of this definition, the National Bureau has identified business cycle peaks and troughs by months, quarters, and years in the United States, Great Britain, France, and Germany. Table 2-1 gives the U.S. chronology, starting in 1834 on an annual basis, and in 1854 on a monthly basis. Monthly figures on economic activity were less abundant than annual data in the early 1800s. During the 150-year period from 1834 to 1984 there were 35 cycles, with an average duration of 51 months. The expansion phases,

Table 2-1 Business Cycle Expansions and Contractions in the United States: 1834-1984*

Dates of Peaks and Troughs				Duration in months			
By months		By years				Cycle	
Trough	Peak	Trough	Peak	Contraction	Expansion	T to T	P to P
		1834	1836		24		
		1838	1839	24	12	48	36
		1843	1845	48	24	60	72
		1846	1847	12	12	36	24
		1848	1853	12	60	24	72
12/1854	6/1857	1855	1856	24	30	84	36
12/1858	10/1860	1858	1860	18	22	48	40
6/1861	4/1865	1861	1864	8	46	30	54
12/1867	6/1869	1867	1869	32	18	78	50
12/1870	10/1873	1870	1873	18	34	36	52
3/1879	3/1882	1878	1882	65	36	99	101
5/1885	3/1887	1885	1887	38	22	74	60
4/1888	7/1890	1888	1890	13	27	35	40
5/1891	1/1893	1891	1892	10	20	37	30
6/1894	12/1895	1894	1895	17	18	37	35
6/1897	6/1899	1896	1899	18	24	36	42
12/1900	9/1902	1900	1903	18	21	42	39
8/1904	5/1907	1904	1907	23	33	44	56
6/1908	1/1910	1908	1910	13	19	46	32
1/1912	1/1913	1911	1913	24	12	43	36
12/1914	8/1918	1914	1918	23	44	35	67
3/1919	1/1920	1919	1920	7	10	51	17
7/1921	5/1923	1921	1923	18	22	28	40
7/1924	10/1926	1924	1926	14	27	36	41
11/1927	8/1929	1927	1929	13	21	40	34
3/1933	5/1937	1932	1937	43	50	64	93
6/1938	2/1945	1938	1944	13	80	63	93
10/1945	11/1948	1946	1948	8	37	88	45
10/1949	7/1953	1949	1953	11	45	48	56
5/1954	8/1957	1954	1957	10	39	55	49
4/1958	4/1960	1958	1960	8	24	47	32
2/1961	12/1969	1961	1969	10	106	34	116
11/1970	11/1973	1970	1973	11	36	117	47
3/1975	1/1980	1975	1980	16	58	52	74
7/1980	7/1981	1980	1981	6	12	64	18
11/1982		1982		16		28	
AVERAGES							
5 cycles, 1834-1855				24	26	50	48
16 cycles, 1854-1919				22	27	48	49
6 cycles, 1919-1945				18	35	53	53

Table 2-1 (Continued)

Dates of Peaks and Troughs				Duration in months			
By months		By years		Cycle			
Trough	Peak	Trough	Peak	Contraction	Expansion	T to T	P to P
8 cycles, 1945–1984				11	45	56	55
35 cycles, 1834–1984				19	32	51	51

SOURCE: National Bureau of Economic Research. Updated by the Author.

*The annual dates are based upon data summed by years. Annual dates may or may not be in the same year as the monthly dates, depending on the behavior of the annual totals.

running from business cycle trough to peak, averaged 32 months. The contraction, or recession, phases kept 19 months on average. The shortest contraction, 6 months, occurred in 1980; the longest, 65 months, was in 1873 to 1878. The longest expansion, 106 months, ran from 1961 to 1969; the shortest expansion, 10 months, came in 1919 to 1920. The most severe business declines in American economy occurred in the cycles that started moving downward in the years 1837, 1873, 1882, 1893, 1920, 1929, and 1937. Crises in the financial markets occurred in all of these cycles. Lesser business declines took place in 1945, 1948, 1953, and 1957, although activity remained at high levels. The year 1873 produced a "Black Friday" on September 19. Heavy speculation in securities, together with the failure of Jay Cook and Co., provided the impetus for the panic, which was brief but severe.

The panic of 1837 began with a suspension of specie payments, widespread bank failures, and wild speculation in commodity markets. Only later did the production and employment decline. The 1882-84 period witnessed railroad securities speculation and subsequent panics as rail failures occurred. In 1893 a heavy gold flow to the London money market led to a suspension of specie payments. This again precipitated a financial crisis and a stock market break. The 1920 break was quite severe but shortlived. Speculation during and immediately following World War I set the stage for a spectacular stock and commodity price crash. By far the most dramatic financial crisis in the entire period was that which began in the United States on Oct. 29, 1929 (Black Tuesday) with the stock market crash. The financial aspects of this crisis were more widespread and lasted longer than in any previous cycle. The bank failures of 1932 and 1933 and the final suspension of the gold standard came at the trough of the cycle, adding greatly to the difficulties of recovery. In 1937 a combination of tightened monetary controls by the Federal Reserve System, increased margin requirements for securities purchase, and a stock market break produced a less severe--but nonetheless sharp--crisis situation. The 1946 and 1949 declines also were both preceded by stock market breaks. In a technical sense these were crises also, although in both instances recovery was rapid and complete (Kinnard 1967, 45-48).

It is evident, over the long span of history covered in Table 2-1, that U.S. business cycles have become somewhat longer, whether measured from trough to trough or from peak to peak. Even more clearly, expansions have become longer relative to contractions. This is true even when one excludes the extraordinarily long expansion from 1961 to 1969. The typical expansion is now about 3 to 4 years, the typical contraction about 1 year (Moore 1982, 95-101).

2.3 Composite Indexes in Current U.S. Business Cycle

In 1937 Wesley Mitchell and Arthur Burns prepared a brief research report that showed types of economic indictors that have been fairly consistent in their timing in relation to business cycle revivals and that are of sufficient general interest to assure some concern by students of current economic conditions. This study was the first of a long series of investigations devoted to extending the system of indicators, testing their performance, explaining the interrelationships among the indicators, and putting the system into practicable form for current use. Since the leading indicators draw much public attention, their reliability is a matter of some importance (Moore 1983, 369). The degree of confidence that any method of analysis inspires depends upon its performance. It must be subjected to trial with new data, not used at that time. In 1950 Geoffrey H. Moore tested the performance of the Mitchell Burns list of the indicators at the 1937 peak and 1938 trough of the business cycle, since the data they had used in their analysis ended with the

1933 trough (Moore 1983, 371).

Business cycles have been defined as sequences of expansion and contraction in various economic processes that show up as major fluctuations in aggregate economic activity--i.e., in comprehensive measures of production, employment, income, and trade. While repeated and pervasive, business cycles of historical experience have been undoubtedly nonperiodic and have changed greatly in duration and intensity, reflecting changes in economic systems, conditions, policies, and outside disturbances.

One of the techniques developed in business cycle research and extensively used as a tool for analyzing contemporary economic conditions and prospects is the cyclical indicator approach. This approach identifies certain economic time series as tending to lead, coincide with, or lag behind the wide movements in aggregate economic activity. Such indicators have been picked up and examined by NBER in a series of studies published between 1938 and 1967. During the 1972-75 period, a new comprehensive study of cyclical indicators was performed by the Bureau of Economic Analysis (BEA) of the Department of Commerce with the collaboration of the NBER research staff.

All cyclical indicators have been assessed according to six major characteristics: economic significance, statistical adequacy, consistency of timing at business cycle peaks and troughs, conformity to business expansions and contractions, smoothness, and prompt readiness (currency). A formal, elaborate weighting system was developed and utilized to evaluate each series by all of the above criteria (Zarnowitz and Boschan 1977). The consequen- tial scores concern the cyclical manner of the series during the period 1947-70. This investigation provided a new list of indicators categorized by economic procedure and typical timing at business cycle peaks and troughs.

This information, especially the scores referring to consistency of timing, served as a ground for the choice of series to be contained on the composite indexes. The indexes include the best-scoring series from many different economic-process groups and incorporate those with similar timing behavior, using their overall performance scores as weights. Composite indexes yield more dependable signals over time than do any of the individual indicators because they utilize series of historically examined practicality and given timing features (for example, leading at both peaks and troughs), with diversified economic coverage and a minimum of repetition. Besides, much of the independent measurement error and other "noise" in the incorporated series are levelled out in the index as a whole.

The principal composite indexes are characterized by their cyclical timing. Therefore, there is an index of leading indicators, series which historically reached their turning points at about the same time as the general economy, and an index of lagging indicators, which contains series that regularly reached their peaks and troughs later than the corresponding business cycle turns.

2.4 Leading Index Studies in Other Industries

Although possibly a fruitful avenue of approach, only two studies were made attempting to use this method for an individual industry. The papers introduced here are about the textile industry and petrolem industry.

2.4.1 Statistical Indicators of the Textile Cycle

Techniques of the National Bureau of Economic Research (NBER) were applied to the textile industry to develop a model to forecast cyclical turning points. To do this, all textile series back to 1953 that were analogous to the NBER indicator series were compiled. It was felt that the nature of the textile industry was sufficiently changed by the introduction of noncellulosic fibers that it was pointless to perform any research prior to World War II and that the

1946–52 period was distorted, first by the immediate postwar recovery and then by the Korean war (Karfunkle 1969).

The effort was concentrated on attempting to forecast the turning points of a "proxy" textile cycle, the Federal Reserve Board's Index of Textile Mill Products(TMP). After the cyclical turning points of the candidate textile series were defined, they were compared both to the "proxy" turning points of the TMP Index and also to each other. Those textile series whose peak and trough turning points usually occurred before both the peaks and troughs of the reference cycle became, by definition, the textile leading indicator series. The textile series selected as leading indicators do not conform 100 percent to the definition.

A set of coincident indicators was developed. By definition, coincident textile indicators are those that peak and trough within three months of the textile reference cycle turning points.

Given the empirically verified fact that the indicators are not 100 percent accurate or perfect, they do not eliminate the need for additional forecasting effort. Not only do data vary, but characteristics of individual series change over time, so that a leading series may cease to lead at some point. The lineup of indicators must be continuously reviewed and reevaluated (Karfunkle 1969, 13-17).

2.4.2 Leading Indicators of the Drilling Cycle

Scot Buell (1985) has demonstrated that there are leading indicators for the U.S. drilling cycle. He identified ten leading indicators. He showed that those leading indicators are supported by regular historical performance and economic reasoning for their leading behavior. Leading indicators were found in the following types of economic time series: the rate of change of the average workweek, prices, drilling success rates, imports, and indicators for the macroeconomy. From the leading indicators identified, an example five-component leading index was prepared. The turning points in the leading index consistently preceded the turning points in the rig count. The author says that this composite leading index is the first of its kind ever prepared for the oil and gas drilling cycle.

The seismic crew count is erroneously considered by many to be a leading indicator of drilling activity. Buell has shown that the seismic crew count is a roughly coincident indicator of drilling activity. Twenty-eight time series based on API drilling statistics were studied.

Most of the API time series were found to be lagging to coincident with the drilling cycle. However, overall drilling success rates and the rate of change of the number of successful exploratory wells completed were found to lead drilling activity.

The major downturn in drilling activity in 1982 had devastating effects on many sectors of the oil and gas industry. The forecasters of drilling activity failed to recognize the major downturn until it was well under way. The leading index developed in the research and future indexes to be developed would reduce the potential of such shock from any future turning points in drilling activity. Leading indexes of drilling activity will serve as a basic management decision tool in the oil and gas industry (Buell 1985, 309-312).

Chapter 3

U.S. ALUMINUM INDUSTRY

3.1 Primary Aluminum Industry

Aluminum has been a metal of industrial importance for more than eighty years because of its unique physical properties. For most of the twentieth century, a small number of producers dominated the aluminum industry. The world aluminum industry has been described as an oligopoly composed of six multinational firms: Alcan Aluminum, Ltd., Aluminum Co. of America (Alcoa), Reynolds Metals Co., Kaiser Aluminum and Chemical Corp., Pechiney Ugine Kuhlman (PUK), and Swiss Aluminum, Ltd. (Alusuisse). Fully integrated, these companies occupy strategic positions in the industry, from producing raw materials to marketing both metal and end products. About 35 percent of world production capacities for bauxite, 50 percent of world alumina capacity, and 40 percent of world aluminum capacity is under their control. In addition, through a variety of consortia arrangements, one or more of these firms is associated with practically all new projects of international significance within the industry. Of the 12 domestic firms producing primary aluminum metal in the United States in 1979, seven owned and imported raw materials from their bauxite and/or alumina facilities in the Caribbean area, South America, Guinea, or Australia (Peterson & Arbelbide 1983).

Until the second World War, the United States represented between 70 percent and 80 percent of the world market in terms of the aluminum ingot production. The overwhelming U.S. dominance of the primary aluminum production has been reduced in the past 40 years to a 24 percent share of world market with 11 major U.S. producers (McCawley & Baumgardner 1985). However, the domestic market has always been dominated by those U.S. producers. Since World War II, two developments changed the structure of the aluminum industry. One was the shift in the geographical distribution of available bauxite, and the other was the development of smelting facilities in Third World countries. These changes resulted in an increase in the number of aluminum producers.

Since the mid-1960s many Third World nations have entered into various aspects of the aluminum industry. The development of aluminum industry activity in the Third World, as in the case of the partially integrated independents, permits more freedom of choice for potential suppliers to, or purchasers from, the aluminum industry. Thus, the control of the industry by so-called oligopoly of the advanced countries has been weakened considerably after the advent of Third World producers (Moreland 1984, 18). On the other hand, in the recycling industry, the development of a volume business in aluminum scrap led to sharper competitive buying practices among consumers of scrap, resulting in an acute shift-away from former buying patterns. The expansion of the scrap industry in the past two decades led many processors to speciallize in the handling of scrap aluminum. These specialists built plants equipped to handle large volume flow of aluminum material and purchased sophisticated equipment to identify, test, process, and package the scrap. One of the interesting phenomena of the 1970s was the proliferation of aluminum merchant-brokers in a field where there had been few such companies in the 1950s and even 1960s. Also, the aluminum scrap export business has become one of the most important aspects of trading. The tremendous demand for aluminum scrap grades, particularly from the Orient (Korea, Japan, and Taiwan), was a decisive market stimulant. There is no doubt that the merchant-broker's role in the aluminum industry, both domestically and internationally, will continue to grow and become even more important in the future (NARI 1981, 35).

3.2 Aluminum Demand Is Cyclical

The demand for aluminum is a derived demand. It is inelastic in regard to price change. For example, in 1984, 137 pounds of aluminum on average was consumed in manufacturing a car Consequently. the value of aluminum was less than $100 per auto, and fluctuations in the price of aluminum are unlikely to affect the market for automobiles. The use of aluminum is increasing in the transportation sector. The price change of aluminum is the result of the change in the economy rather than a causal fact. Two-thirds of aluminum demand is for three industries: construction, transportation, and capital goods. The application of aluminum in these sectors is postponable because the decision of consumers is bound to the income change and interest change. In recent years, inventories have been shallow because of effective computer systems and high interest rates. Table 3-1 shows the change in the U.S. aluminum demand over the period 1960-84.

Building permits are usually six months ahead of housing starts. The building and construction sector is heavily interest dependent. There has been downsizing of houses due to high interest rates. The automobile industry is heavily cyclical and slow growing in the long run. The

Table 3-1 Aluminum Demand in the United States
(in billions of pounds)

Sectors	1984	1983	1979	1970	1960
Building & Construction	2.86	2.87	3.05	2.25	1.22
Transportation	2.94	2.34	3.02	1.55	.85
Consumer Durables	1.11	1.05	1.01	.93	.51
Electrical	1.49	1.30	1.56	1.36	.53
Machinery & Equipment	0.83	0.78	.93	.61	.33
Containers & Packaging	4.04	3.92	3.22	1.47	.32
Other	1.09	0.65	.64	.79	.35
Total Domestic Shipments	14.35	12.91	13.86	8.96	4.11
Export	1.08	1.24	1.02	1.15	.62
Total	15.43	14.15	14.89	10.11	4.73

Source: Aluminum Association, 1985

container and packaging industry is not cyclical and has been growing fast because of consumer preference for aluminum cans. In 1984 the containers and packaging sector consumed 28 percent of the total domestic demand, thus solidifying its position of largest consumer. In the same year, the consumption of aluminum overall was 61 pounds per person in the United States and 6 pounds per person in the rest of the world.

3.3 Prices of Aluminum

There are three major prices in the primary ingot market: producers' price, midwest ingot price, and LME ingot price. For a long time, the producers' price dominated the market. The fact that a small number of producers dominated the market helped keep the price system stable. However, during the last 20 years there has been a tremendous expansion in the number of producers all over the world, reducing the market controlling power of major companies. The competition and, therefore, price volatility, has increased. A contract for aluminum ingot in the midwest market gained recognition in 1972. The price as quoted in Metalsweek has served as a free market index of aluminum ingot price. However, there was a need for a more organized market for aluminum ingot including forward contracts. In 1978, the LME started the aluminum forward market which has since served as a hedging mechanism for many segments of aluminum industry. The LME aluminum contract has been operated for more than seven years and aluminum has become one of the most heavily traded metals on the LME, rivaling copper for the top position.

During 1984, two changes in world pricing policies were implemented by major foreign producers. Pechiney of France began the Pechiney Independent Price (PIP) index. The index is calculated quarterly and is based on Pechiney's sales of 99.5 percent ingot to independent customers. The index is the ratio of the quarterly average price per ton to the

1975 selling price, the base year with an index of 100. In October 1984, the published Alcan World Price was withdrawn by Alcan Aluminum. This price had provided the benchmark for worldwide aluminum export sales for many years (Metal Bulletin Monthly 1984). The trend of producers' prices is shown in Appendix B, Figure B-10. The midwest price series which has a longer history than the LME price series was found to show similar ups and downs with the latter. Both prices were considered as a subject of this research. However, the history of the LME price and the midwest price of primary aluminum ingot is too short to compare with other time series related to the aluminum industry. The scrap price series led these two price series, making itself as subject of forecasting. The free market price of aluminum scrap has a much longer history than the market prices of primary aluminum ingot. The starting date of cast aluminum scrap price goes back to 1933 in the publication, Metal Statistics. The scrap market is characterized by a large number of purchasers and suppliers, satisfying the condition for a free market.

3.4 Recycling Industry

Recovery of purchased scrap contributes some 30 percent of the total domestic supply of aluminum (Kaufmann 1983).

Scrap is divided into two main categories, new scrap and old scrap. New scrap is generated in manufacturing primary aluminum, semi-fabricated aluminum mill products, or finished industrial and consumer products. New scrap includes solids, such as new casting scrap; clippings or cuttings of new sheet, rod, wire, and cable; borings and turnings from the machining of aluminum parts; and residue, drosses, skimmings, spillings, sweepings, and foil (Stamper et al. 1978, 29).

Old scrap, from discarded, used, and worn-out products, includes aluminum engine or body parts from junked cars, used aluminum cans and utensils, and old wire and cable (Kurtz et al. 1981, 9-34). The proportion of total domestic metal consumption met by the recovery of old scrap amounted to about 13 percent in 1984 (the Aluminum Association 1985).

In the secondary industry, production is from scrap, not ores. Just as the primary industry mines from stocks of ore and ore quality is determinant of primary industry cost, the secondary industry can be considered as "mining" from stocks of scrap, and scrap quality is determinant of secondary production cost. In contrast to the primary industry, which is an oligopoly, the secondary aluminum industry approximates the perfectly competitive model: that is, there are enough secondary establishments so that each firm can ignore its effect on price.

However, because primary and secondary metals are close substitutes, secondary price is not determined by the intersection of the industry supply and demand curves, as with the perfectly competitive model. Price is given to the secondary industry and is closely related to primary price. However, primary producers' price, which is based on long-run average cost, is fairly stable while secondary price is more volatile and fluctuates with short-run changes in economic activity (Slade 1980, 228).

In the United States, 50 percent of scrap aluminum recovery is from new scrap (Aluminum Association 1985b). In contrast to the consumption of steel and copper scrap by both primary and secondary metal producers, aluminum scrap for foundry applications is consumed by secondary producers in the United States. Since mixtures of alloy elements and impurities continue to build up in certain types of secondary aluminum alloys, primary aluminum cannot be commercially refined from alloyed and impure scrap (Fisher et al. 1981, 228).

In the secondary aluminum, the scrap is remelted partly for alloy material with silicon or carbon added, and the rest is used for the production of secondary ingot with impurities. Used beverage cans (UBC) are the biggest source of the secondary ingot production. Sixty percent of cast aluminum is produced in foundries for the automobile industry. Aluminum manufacturers in general do not have remelting facilities. Therefore, scrap metal is sent to the smelters or foundries.

New scrap is produced by smelters and fabricators. The old scrap is mostly from shipscrapping, automobiles, and producers' durables. Sweat furnaces separate aluminum from iron by heating old scrap at temperatures greater than the melting point of aluminum, but lower than the melting point of iron.

There is no price control of scrap by buyers or sellers. Both supply side and demand side of scrap are price inelastic. There is a tremendous gyration in scrap prices. However, secondary producers have only a limited capability to boost output in response to high prices. Because the raw material for their output is scrap aluminum, and over four-fifths of scrap aluminum recovery is new scrap, the supply of new scrap is essentially a function of current consumption of aluminum. And it is not likely that the supply of old scrap is highly price responsive (Woods et al. 1980, 74).

Chapter 4

DATA PREPARATION

4.1 Statistical Data in the Aluminum Industry

The statistical data relevent to this research was gathered from various sources. The sources and time periods covered are shown in Table 4-1. The seasonal adjustment was applied if needed for the analysis.

4.2 Dates of Turning Points

After they were processed for the seasonal adjustment, graphs of time series were generated from those data. Then, peaks and troughs of each graph were picked out. Dates of those turning points are shown in Table 4-2. Graphs of these time series are attached in Appendix B. The methodology of dating turning points was as follows: 1) Find monthly statistical data for the relevant time series in the U.S. aluminum industry and get index values of each series. 2) Prepare a graph of index values along the time period for each series. If there is seasonality in the data, prepare a graph of seasonally-adjusted data. 3) Date turning points of peaks and troughs of each time series. 4) Compare these turning points to those of Aluminum Shipments and Aluminum Scrap Prices. 5) Classify those time series as

Table 4-1 Source of Aluminum Data (monthly)

Name of Series	Time Period	Data Source
Prices of New Clippings	1/48 - 12/84	Metal Statistics
Producers' Prices, Primary Ingot	1/48 - 12/84	Metal Statistics
Midwest Prices, Primary Ingot	1/72 - 12/84	Metal Bulletin
All Employees Nos. in Pri. Al Indus.	1/64 - 12/84	Employment and Earnings
No. of Pro. Workers in Pri. Al Indus.	1/64 - 12/84	Employment and Earnings
Aver. Wkly. Hrs. of Prod. Worker	1/64 - 12/84	Employment and Earnings
Aver. Wkly. Overtime Hrs. of Pro. Worker	1/72 - 12/84	Employment and Earnings
Al Ingot Cash Prices in LME	1/79 - 12/84	Non-ferrous Metal Data
Aver. Hrly. Earnings of Pro. Worker	1/64 - 12/84	Employment and Earnings
Primary Al Production	1/48 - 12/84	Survey of Current Business
Al Shipments	1/57 - 12/84	Survey of Current Business
Al Imports	1/64 - 12/84	Survey of Current Business
Al Exports	1/64 - 12/84	Survey of Current Business
Producers' Inventory Change	1/67 - 12/84	Commodity Yearbook
Cast Al Scrap Prices	1/48 - 12/84	Metal Statistics

Table 4-1 (Continued)

Name of Series	Time Period	Data Source
Monthly Sales of Cars	1/58 - 12/84	Citibase
Mobile Home Shipments	1/58 - 12/84	Citibase
Local Building Permits	1/48 - 12/84	Citibase
Stock Aver. of Non-Ferrous Metal Mining	1/48 - 5/85	American Metal Market
Al Scrap Recovery	1/53 - 4/85	Survey of Current Business

Table 4-2 Dates of Turning Points

Time Series		Dates of Turning Points				
Prime	P	2/54	12/57	7/60	2/70	8/74
Rate	T	7/55	8/58	11/65	3/72	4/77
	P	8/81				
	T	3/83				
Stock	P	8/56	7/59	4/66	10/73	5/77
Price, Al	T	1/58	6/62	11/71	12/74	2/78
Smelters	P	4/81	1/84			
	T	6/82	7/84			
New Or-	P	3/66	1/69	2/73	1/79	8/83
ders, Al	T	3/67	3/70	2/75	11/81	6/84
Al Ingot	P	10/48	7/56	2/60	7/70	4/74
Produc-	T	11/49	7/58	4/61	11/71	10/75
tion	P	3/81				
	T	2/83				
Local	P	--	11/58	2/64	1/66	2/69
Building	T	2/58	12/60	4/65	11/66	1/70
Permits	P	12/72	8/77	9/80	2/84	
	T	3/75	4/80	10/82		
Mobile	P	--	7/64	1/69	3/73	10/77
Home Ship-	T	9/61	1/67	2/70	1/75	8/78
ments	P	8/79	4/81	8/83		
	T	5/80	9/82			
Monthly	P	9/60	1/66	8/68	3/73	12/76
Sales	T	2/61	11/67	11/70	11/74	12/81
of Cars	P	2/84				
	T	--				
Hrs Worked	P	4/65	12/68	8/72	4/74	5/76
Weekly in	T	2/66	8/71	3/73	6/75	1/77
Primary Al	P	6/78	10/80			
Industry	T	7/79	12/82			
Al Ship-	P	--	7/59	8/66	7/69	10/73
ments	T	3/58	1/61	3/67	11/70	3/75
	P	1/79				
	T	12/81				

Table 4-2 (Continued)

Time Series		Dates of Turning Points				
Cast Al Scrap Prices	P	12/48	6/51	10/55	4/60	7/65
	T	7/49	7/52	7/58	2/63	10/67
	P	8/69	4/74	3/80	4/84	
	T	2/72	3/75	12/82		
Leading Index of Business Cycle	P	--	5/59	4/69	3/73	3/79
	T	2/58	12/60	10/70	2/75	5/80
	P	4/81				
	T	3/82				
Stock Price of Nonferrous Mining	P	--	2/59	5/61	1/66	12/68
	T	12/57	3/60	10/62	8/66	7/72
	P	2/74	6/76	3/81	5/83	
	T	9/74	12/78	6/82		
MW Ingot Price	P	--	8/74	2/80	8/83	
	T	1/73	12/75	6/82		
Inventory Change (Inverted)	P	--	4/74	3/80	4/84	
	T	2/72	3/75	12/82		
Growth Rate of Earnings	P	6/68	8/71	3/74	9/77	9/81
	T	4/70	4/73	12/75	8/78	
All Employees Numbers	P	6/70	12/74	3/80	4/84	
	T	3/72	11/75	3/83		
Production Workers Numbers	P	3/70	12/74	3/80	3/84	
	T	3/72	11/75	3/83		
Weekly Overtime Hours	P	4/74	4/76	2/78	3/84	
	T	4/75	4/77	10/82		
Aluminum Imports	P	--	12/65	3/68	1/73	4/76
	T	1/65	7/67	9/70	5/75	1/77
	P	10/78				
	T	5/80				

Table 4-2 (Continued)

Time Series		Dates of Turning Points				
Aluminum	P	--	2/67	1/70	11/73	1/76
Exports	T	4/66	12/67	10/71	3/75	10/77
	P	1/79	9/80	6/82		
	T	6/79	9/81			
Net Import	P	2/66	3/68	3/72	11/74	5/78
Aluminum	T	7/67	6/70	11/73	5/75	8/80
	P	9/81				
	T	10/82				
Leading	P	--	11/50	3/53	12/55	7/59
Index of	T	6/49	4/52	7/54	4/58	1/61
Inflation	P	1/66	4/69	3/73	3/79	
	T	4/67	11/70	6/75	12/82	

leading, coincident, or lagging indicators to the reference series. 6) Construct composite leading indexes for Aluminum Shipments and Aluminum Scrap Prices. 7) Compare action of leading indexes to the history of the series in question to test how frequently the index worked. 8) If consistent, test also to see if a consistent period of time existed between turning points of the index and the turning points of subject series. 9) Analyze causes and effects of these results.

4.3 Leading Indicator Analysis of Aluminum Shipments

Eighteen time series were compared to the volume of U.S. aluminum shipments. Among them, six series were selected as leading indicators of the Aluminum Shipments. They are 1) Local Building Permits, 2) New Orders of Aluminum, 3) Leading Index of U.S. Business, 4) Mobile Home Shipments, 5) Monthly Sales of Cars, and 6) Stock Price Composite of Nonferrous Metal Mining Industry. The performances of those leading indicators are shown in Table 4-3. Other indicators were mostly lagging to the Aluminum Shipments. Some of them, such as Hours Worked Weekly and Net Imports of Aluminum, were not classifiable when they were compared to Aluminum Shipments. The performance of those other indicators is shown in Table 4-4. Charts

Table 4-3 Leading Indicators for Aluminum Shipments

LEADING INDICATOR	PERIOD COVERED		Leads	Number of Coincidences Rough	Number of Coincidences Exact	Lags	Median Lead or Lag, in Months
Local Building Permits (SHSBP)	1/48 - 4/85	Peaks	5	0	0	0	-8
		Troughs	4	2	1	1	-1
		Total	9	2	1	1	-5
New Orders of Aluminum (CNEWS)	1/64 -12/84	Peaks	4	0	1	0	-6
		Troughs	3	2	1	0	-1
		Total	7	2	2	0	-3
Leading Index of U.S. Business (DLEAD)	1/48 - 4/85	Peaks	3	3	0	1	-2
		Troughs	4	5	0	1	-1
		Total	7	8	0	2	-1
Mobile Homes Shipments (HMOB)	1/59 - 4/85	Peaks	4	0	0	1	-7
		Troughs	3	2	0	2	-2
		Total	7	2	0	3	-4
Monthly Sales of Cars (RCARD)	1/58 - 4/85	Peaks	4	0	1	1	-7
		Troughs	1	1	2	2	0
		Total	5	1	3	3	0
Stock Price Composite of Non-ferrous Metal Mining Industry (METALS)	1/48 - 8/84	Peaks	4	0	0	2	-6
		Troughs	4	1	0	2	-4
		Total	8	1	0	4	-6
Leading Index of Aluminum Shipments(A2LD1):SHSBP, CNEWS, DLEAD, RCARD	1/57 - 4/85	Peaks	5	1	1	0	-6
		Troughs	2	2	3	0	0
		Total	7	3	4	0	-2
Leading Index of Aluminum Shipments(A3LD1):SHSBP, CNEWS, DLEAD, RCARD, HMOB	1/58 - 4/85	Peaks	5	0	1	0	-6
		Troughs	3	3	1	1	-1
		Total	8	3	2	1	-4
Leading Index of ALuminum Shipments(A5LD1):SHSBP, CNEWS, DLEAD, HMOB	1/57 - 4/85	Peaks	6	2	0	0	-4
		Troughs	5	4	1	0	-2
		Total	11	6	1	0	-2
Leading Index of Aluminum Shipments(X2LD1):SHSBP, CNEWS, DLEAD, HMOB, METALS	1/57 - 4/85	Peaks	4	1	1	1	-4
		Troughs	3	4	1	2	0
		Total	7	5	2	3	-2

Table 4-4 Other Indicators of Aluminum Shipments

Name of Indicator, Period Covered		Number of Leads	Coinci. Rough	Coinci. Exact	Lags	Median Lead or Lag in Months
Stock Price Index	P	4	0	0	2	-6
Nonferrous Metal	T	4	1	0	2	-4
(48-84)	Tot.	8	1	0	4	-6
Midwest Price,	P	1	0	0	2	+10
Al Ingot	T	0	0	0	2	+8
(72-84)	Tot.	1	0	0	4	+9
Inventory Change	P	1	0	0	0	-13
Producers' Al	T	0	0	0	2	+16
(72-84)	Tot.	1	0	0	2	+15
Growth Rate of	P	1	0	0	2	+5
Earnings	T	1	0	0	1	+1
(64-84)	Tot.	2	0	0	3	+5
All Employees	P	0	1	0	4	+11
Numbers	T	0	0	0	3	+15
(64-84)	Tot.	0	1	0	7	+14
Nos., Production	P	0	1	0	4	+11
Workers	T	0	0	0	3	+15
(64-84)	Tot.	0	1	0	7	+14
Al Ingot Produc-	P	0	0	0	4	+10
tion	T	0	1	0	4	+7
(48-84)	Tot.	0	1	0	8	+7
Hours Worked	P	2	0	0	1	-7
Weekly	T	1	1	0	3	+6
(64-84)	Tot.	3	1	0	4	+3
Weekly Overtime	P	1	1	0	2	+1
Hours	T	0	1	0	2	+6
(72-84)	Tot.	1	2	0	4	+1
Al Imports	P	4	1	0	0	-8
(64-84)	T	2	2	0	2	0
	Tot.	6	3	0	2	-6

Table 4-4 (Continued)

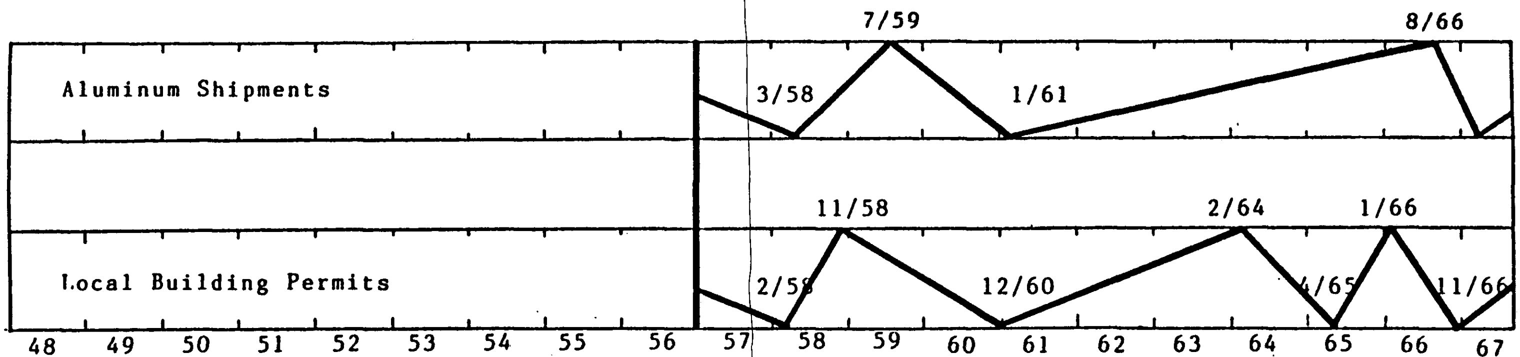
Name of Indicator, Period Covered		Number of Leads	Coinci. Rough	Coinci. Exact	Lags	Median Lead or Lag in Months
Al Exports	P	1	1	1	3	+1
(64-84)	T	1	1	1	2	+4
	Tot.	2	2	2	5	+1
Net Imports of	P	4	0	0	0	-12
Aluminum	T	1	1	0	3	+3
(64-84)	Tot.	5	1	0	3	-6

comparing each time series with Aluminum Shipments were prepared.

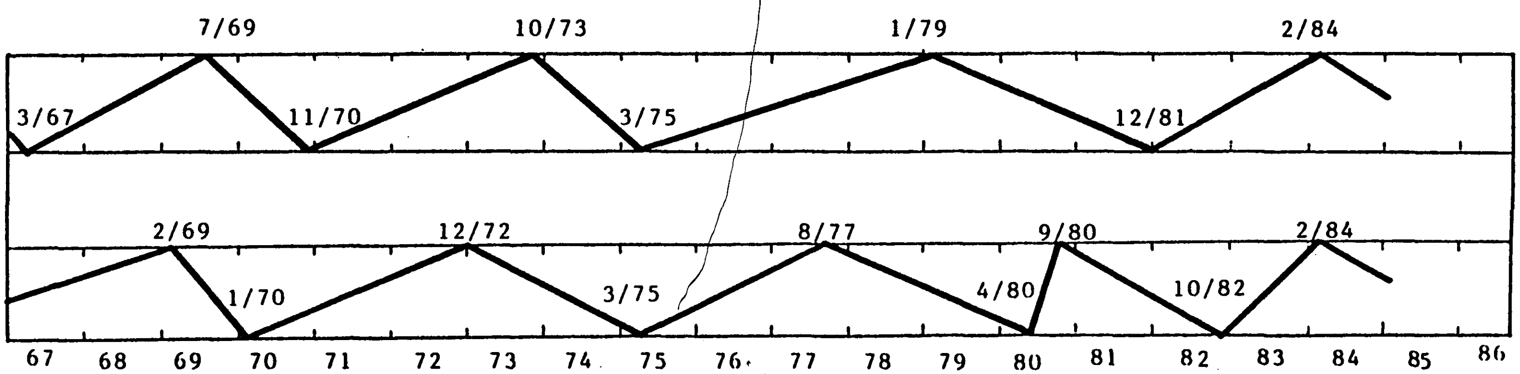
4.3.1 Local Building Permits

As shown in Chart 4-1, the peaks and troughs of Local Building Permits mostly led the peaks and troughs of Aluminum Shipments. There were 12 turning points in Aluminum Shipments that were comparable to those of Local Building Permits. Local Building Permits had five leads in peaks and four leads in troughs. There was no coincidence in peaks. However, in trough-to-trough comparison there were two coincidencies. In addition, there was one lag of the trough in Local Building Permits. As a result, the peaks of Local Building Permits had a median of eight months lead to those of Aluminum Shipments, while the troughs of Local Building Permits had the median of one month lead to those of Aluminum Shipments. Considering whole turns of peaks and troughs, Local Building Permits had five months' lead. There were four extra turns in Local Building Permits. The lead of Local Building Permits to Aluminum Shipments was in fact expected because Local Building Permits is a leading indicator of the U.S. Business Cycle which is a coincident indicator of Aluminum Shipments. Therefore, with the performance explained and

Chart 4-1 Aluminum Shipments vis-a-vis Local Building Permits



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS		7/59	8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)		-8	-7	-5	-10	-17	0				6	0	5	0	1	0	-8	-8	6	2
TROUGHS	3/58	1/61	3/67	11/70	3/75	12/81														
L(-) or Lg(+)	-1	-1	-4	-10	0	10					6	0	4	2	1	1	-1	-1	7	2
P and T											12	0	9	2	2	1	-4	-4	7	4



shown in Chart 4-1, Local Building Permits was classified as a leading indicator of Aluminum Shipments. The ten-month lag of Local Building Permits at the trough in September 1982 was ignored.

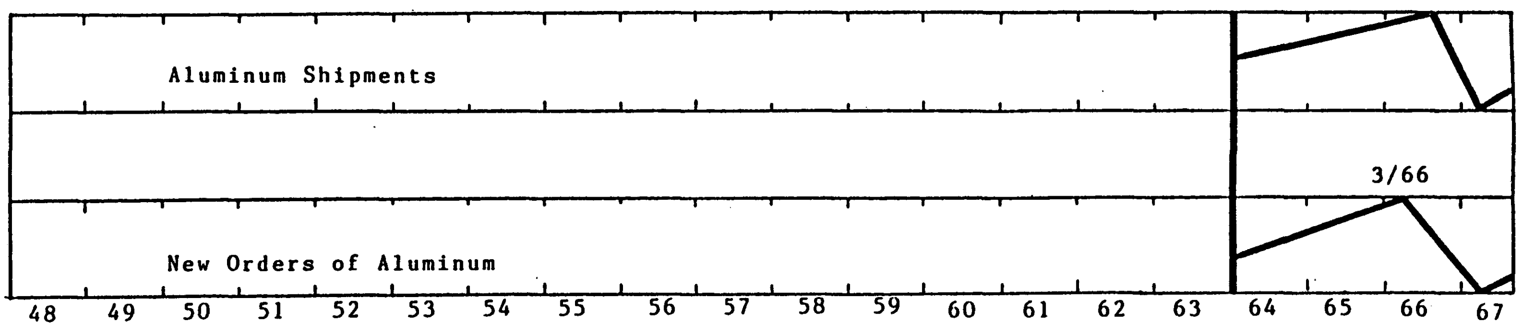
4.3.2 New Orders of Aluminum

The statistical data of New Orders of Aluminum begin in January 1964, leaving only five peaks and four troughs to be compared. There was one extra turn of the trough in New Orders of Aluminum in June 1984, which would be another leading trough to the coming trough of Aluminum Shipments that was not yet discovered in 1984. In the peak-to-peak comparison, New Orders had four leads and one exact coincidency with a median lead of six months. In the trough-to-trough comparison, New Orders had three leads and three coincidencies with a median lead of only one month. As a whole, there were seven leads and four coincidencies with a median lead of five months. The tendency that peaks of New Orders are mostly leading, while half of the troughs of New Orders show coincidencies is similarly found in the comparison of Local Building Permits to Aluminum Shipments. This means that when a leading indicator starts to go into recession, Aluminum Shipments tends to assimilate to the recession in a very short time. This adaptation to the reduction of demand is more often found after 1975. It is probably due to the computerization of the inventory control in the primary industry and also by fabricators, which enabled them to react to the market change faster than before. The performance of New Orders is shown in Chart 4-2.

4.3.3 Leading Index of Business Cycle

Leading Index of Business Cycle is a composite index of Business Cycle established by the Bureau of Economic Analysis. It is based on twelve leading indicators in the general economy. In Chart 4-3, Leading Index of Business Cycle is compared to Aluminum Shipments. There were twelve turns of peaks and troughs in Aluminum Shipments. Three turns among them were extra because Leading Index of Business Cycle didn't have any turn around those turns. Therefore, only nine turns were comparable to those in Leading Index of Business Cycle. In the peak-to-peak comparison there were three leads and three coincidencies and one lag by the Leading Index, with a median lead of two months. In the trough-to-trough comparison, the Leading Index of Business had four leads, five coincidencies, and one lag with median lead of one month. Generally, the Leading Index had seven leads, eight coincidencies, and two

Chart 4-2 Aluminum Shipments vis-a-vis New Orders of Aluminum



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-)or Lg(+)			-5	-6	-8	0	-6				5	0	4	0	1	0	-6	-5	3	0
TROUGHS			3/67	11/70	3/75	12/81														
L(-) orLg(+)			0	-8	-1	-1					4	0	3	2	1	0	-1	-3	4	1
P and T											9	0	7	2	2	0	-5	-4	3	1

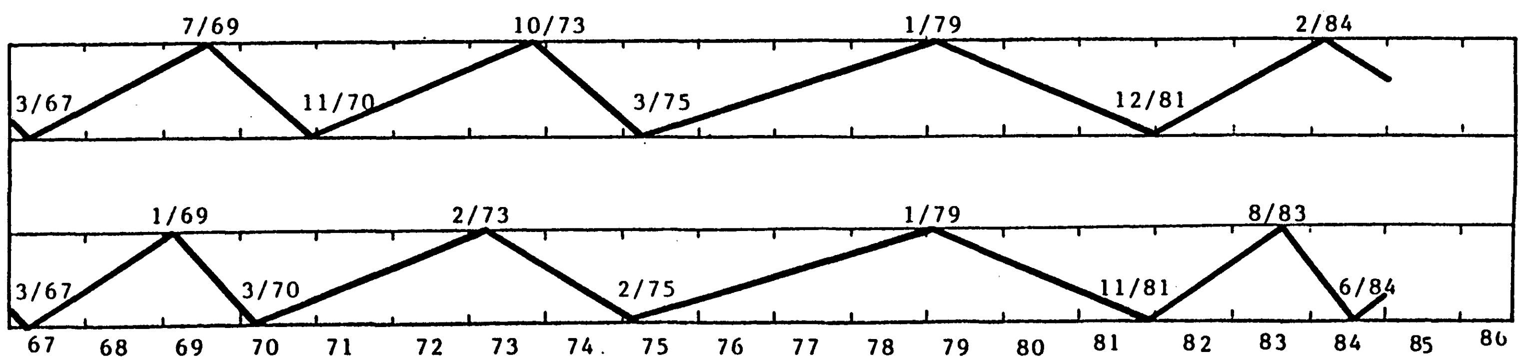
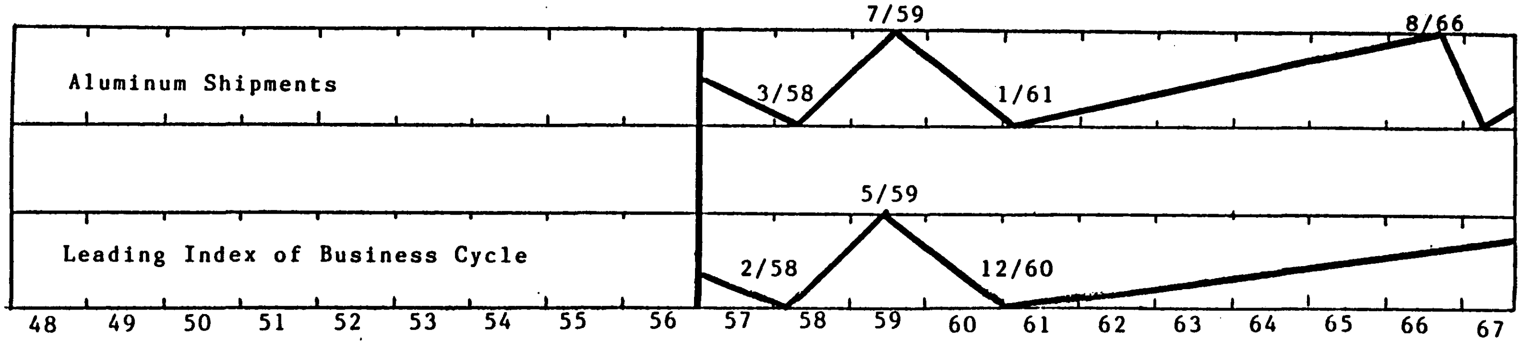
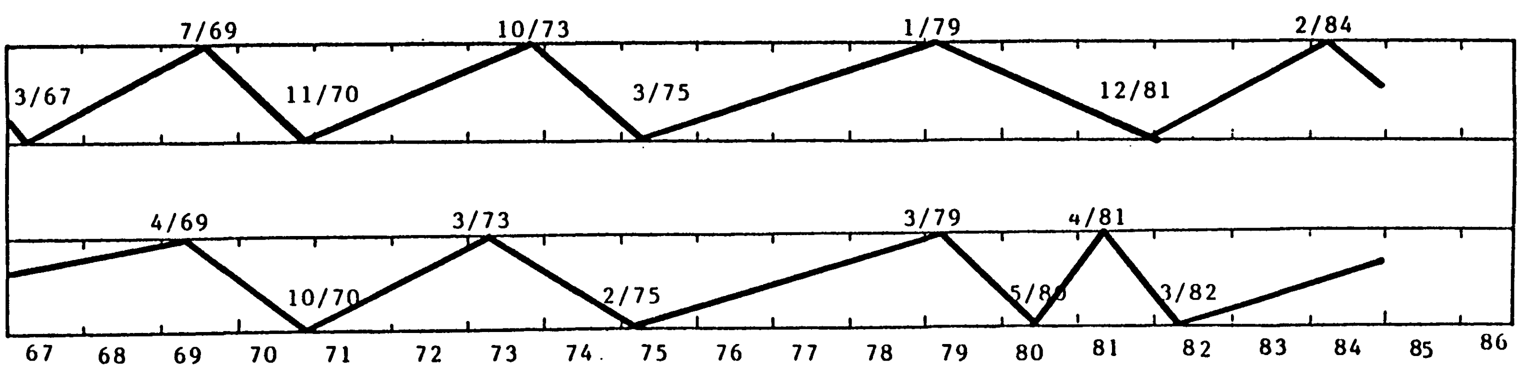


Chart 4-3 Aluminum Shipments vis-a-vis Leading Index of Business Cycle



											No. of Observ.	Skipped Turns	Number of L(-)	Number of ±3	Number of 0	Number of Lg(+)	L(-) or Lg(+) Md	L(-) or Lg(+) Mn	Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS		7/59	8/66	7/69	10/73	1/79	2/84													
L(-)or Lg(+)		-2	-	-3	-7	2	-				6	2	3	3	0	1	-2	-3	4	1
TROUGHS	3/58	1/61	3/67	11/70	3/75	12/81														
L(-) orLg(+)	-1	-1	-	-1	-1	3					6	1	4	5	0	1	-1	0	2	1
P and T											12	3	7	8	0	2	-1	-1	3	2



lags with median lead of one month. The number of coincidencies is double-counted if there are any leads or lags within three months. Although there were eight coincidencies, the Leading Index of Business Cycle can still be considered a leading indicator because there were seven leads and only two lags. A similar tendency is found in the trough-to-trough comparison which shows that the Leading Index is more or less coincident with Aluminum Shipments, as was found in the previous two time series comparisons.

4.3.4 Mobile Home Shipments

The statistical data of Mobile Home Shipments begin in January 1959. There were seven peaks and seven troughs in Mobile Home Shipments between 1959 and 1984. There were four extra turns between 1977 and 1981. When ten turning points of Mobile Homes Shipments were compared to those of Aluminum Shipments, there was an irregular pattern of the leads by Mobile Homes Shipments. Mobile Homes Shipments was leading in the peak-to-peak comparison. However, in the trough-to-trough comparison, the relationship of troughs of Mobile Homes Shipments to those of Aluminum Shipments was not consistent enough for any classification to be available. If the extra turns in the 1977-1981 time period were ignored, there could have been a better results. The dates of extra turning points are as follows:

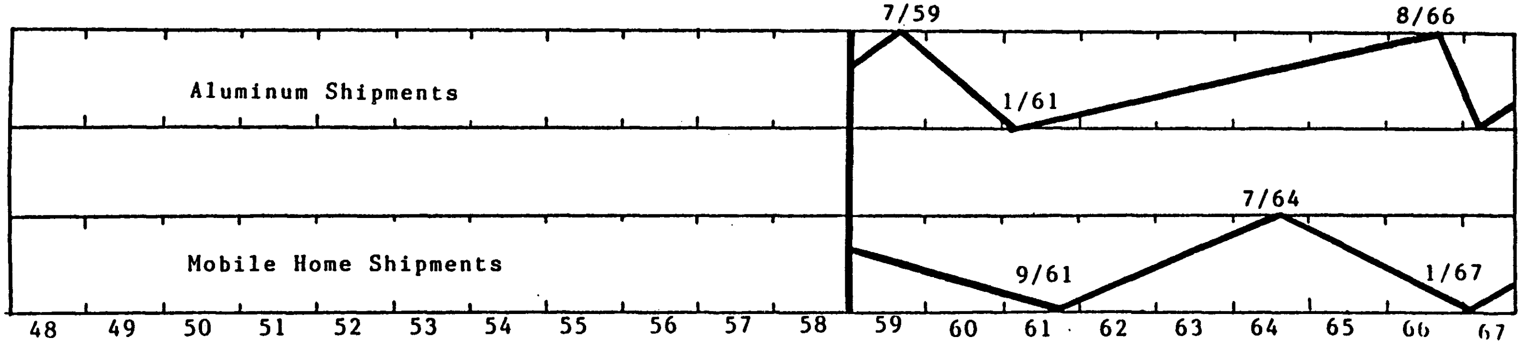
Extra Turns in Mobile Home Shipments	Date
peak	10/77
trough	8/78
trough	5/80
peak	4/81

For those two extra cycles there were no relevant cycles shown in Aluminum Shipments. Because the mobile home industry is interest-sensitive as is the housing industry, the extra fluctuations of mobile home shipments are due to the fluctuations of interest rates during the 1977-81 period when the interest rate marked its upcoming trend. Chart 4-4 explains the irregularity of the relationship of the two time series.

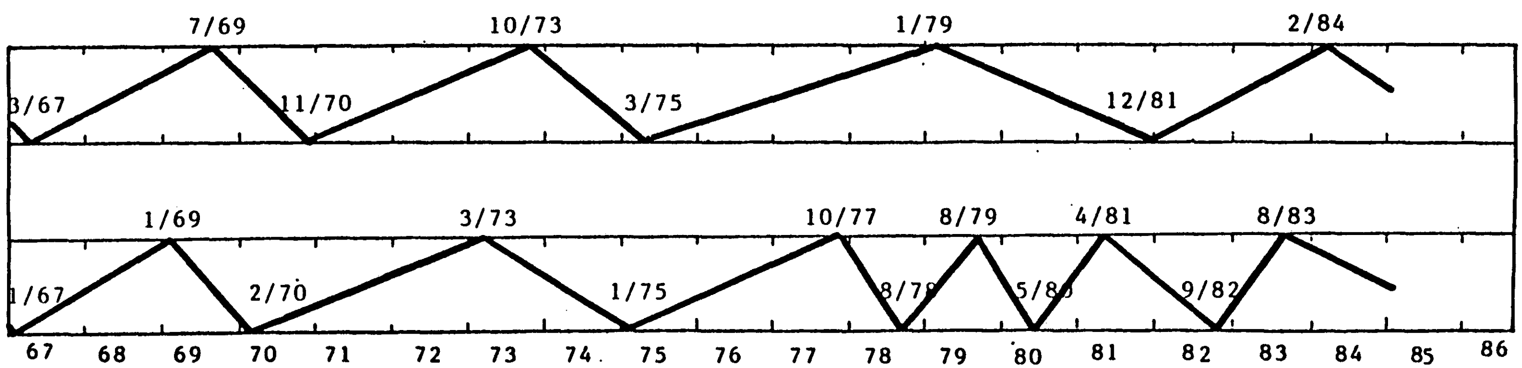
4.3.5 Monthly Sales of Cars

The transportation industry is a main demand sector for aluminum. Aluminum is consumed for the manufacture of castings for engine bodies. The demand of aluminum in this

Chart 4-4 Aluminum Shipments vis-a-vis Mobile Home Shipments



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS		7/59	8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	lg(+)	Md	Mn		
L(-)or Lg(+)		–	-25	-6	-7	7	-6				6	1	4	0	0	1	-6	-7	11	2
TROUGHS		1/61	3/67	11/70	3/75	12/81														
L(-) orLg(+)		8	-2	-9	-2	9					5	0	3	2	0	2	-2	1	8	2
P and T											11	1	7	2	0	3	-4	-3	10	4

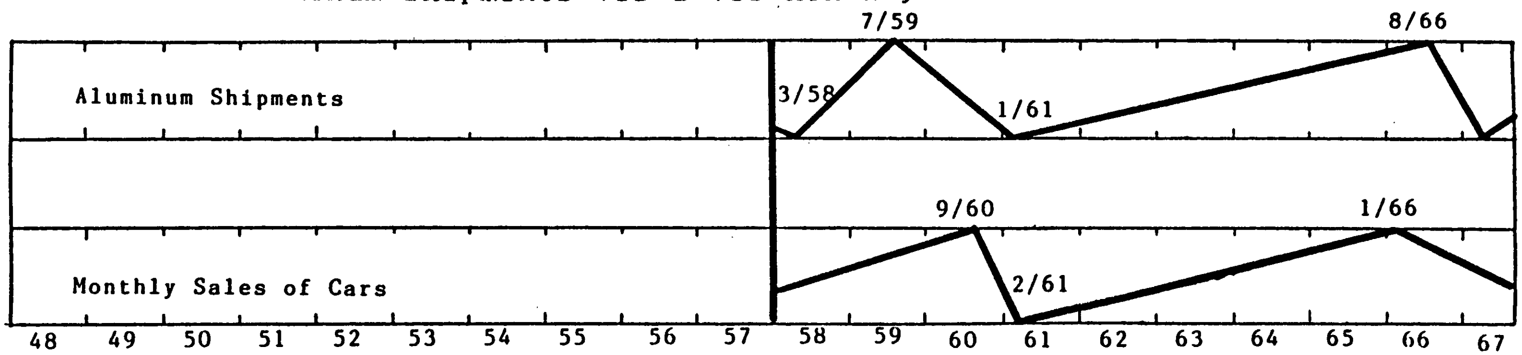


sector has been increasing because of a trend toward reducing car weight by replacing steel and copper with aluminum. Chart 4-5 shows the relationship of turns between Aluminum Shipments and Monthly Sales of Cars. There were twelve turns with no extra turns in Monthly Sales of Cars in the covered period. There were five leads, three exact coincidencies, and three lags by the turns of car sales. Two of the lags took place in between 1960 and 1961 when aluminum was barely used in the car manufacturing industry. In the trough-to-trough comparison, the chart shows a rather coincident trend which is also noticed in the comparisons with the time series of Local Building Permits and New Orders of Aluminum. The lag of the turn in Car Sales in November 1967 seems to have nothing to do with the movement of Aluminum Shipments. Rather, the lag would be related to factors in other industries. Trends after 1981 show exact coincidencies of turning points which may be due to shrewder control of aluminum inventories.

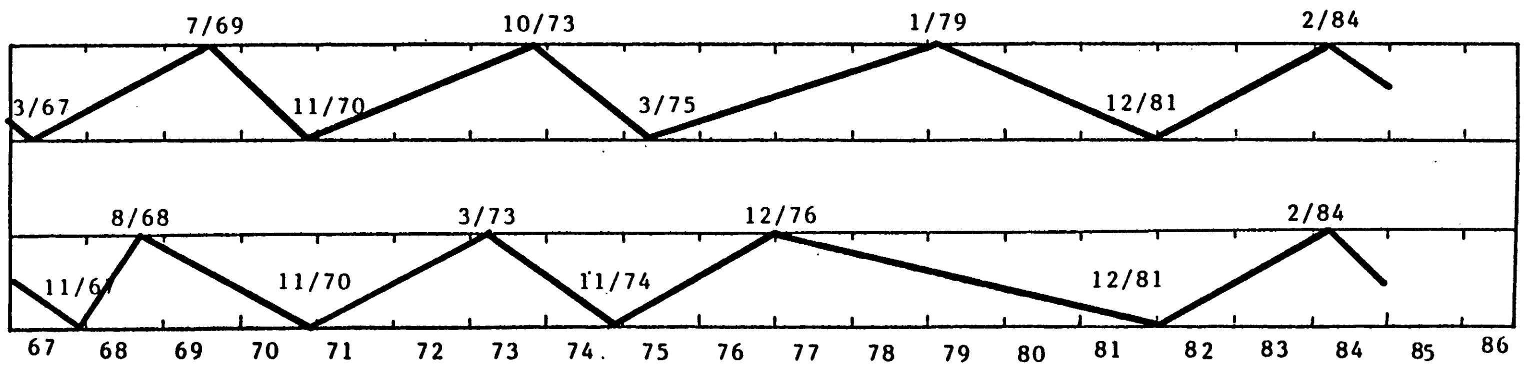
4.3.6 Stock Price Index of the Nonferrous Metal Mining Industry

Stock Price Index of Nonferrous Metal Mining Industry is the composite index of stock exchange prices of copper, zinc, lead, and some other nonferrous metal mining

Chart 4-5 Aluminum Shipments vis-a-vis Monthly Sales of Cars



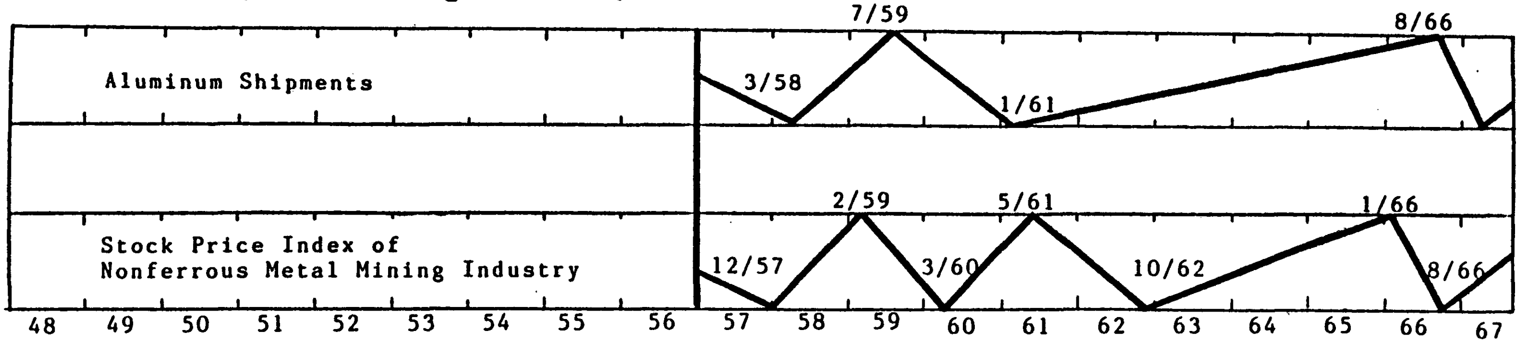
										No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS		7/59	8/66	7/69	10/73	1/79	2/84					L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)		14	-7	-11	-7	-25	0			6	0	4	0	1	1	-7	-6	13	0
TROUGHS	3/58	1/61	3/67	11/70	3/75	12/81													
L(-) or Lg(+)	–	1	8	0	-4	0				6	1	1	1	2	2	0	1	4	0
P and T										12	1	5	1	3	3	0	-3	10	0



companies. As there is no strong bauxite mining activity in operation in the United States, there is no direct relationship of the Stock Price Index to Aluminum Shipments. However, this comparison was considered because the activity of the nonferrous metal mining industry could affect that of the aluminum industry. There were more leads (8) than lags (4) by the turns in the Stock Price Index. Still, there were four extra turns in the Stock Price Index. The tremendous size of lags of the trough in July 1972 and the peak in March 1981 are difficult to explain for the aluminum industry. Stock Price Index of Nonferrous Mining Industry turns out to be ineffective as a leading indicator for the construction of the composite leading index of Aluminum Shipments. Chart 4-6 shows the results of comparison of these two time series.

Chart 4-7 shows the nonconformity of the turns of Stock Price Index of Aluminum Smelters to those of Aluminum Shipments. The most irrelevant occurrences of turns were in the 1977-81 time period, with two extra turns. Totally, the Stock Price Index had four leads, five coincidencies, and four lags. Therefore, it was not classifiable. It means the fact that the stock price index of the general economy leads the business activity cannot be copied in specific sectors such as the aluminum industry. The movement of

Chart 4-6 Aluminum Shipments vis-a-vis Stock Price Index of Nonferrous Metal Mining Industry



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS		7/59	8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)		-6	-7	-7	4	26	-9				6	0	4	0	0	2	-6	0	13	2
TROUGHS	3/58	1/61	3/67	11/70	3/75	12/81														
L(-) or Lg(+)	-3	-10	-7	20	-6	6					6	0	4	1	0	2	-4	0	11	2
P and T											12	0	8	1	0	4	-6	0	12	4

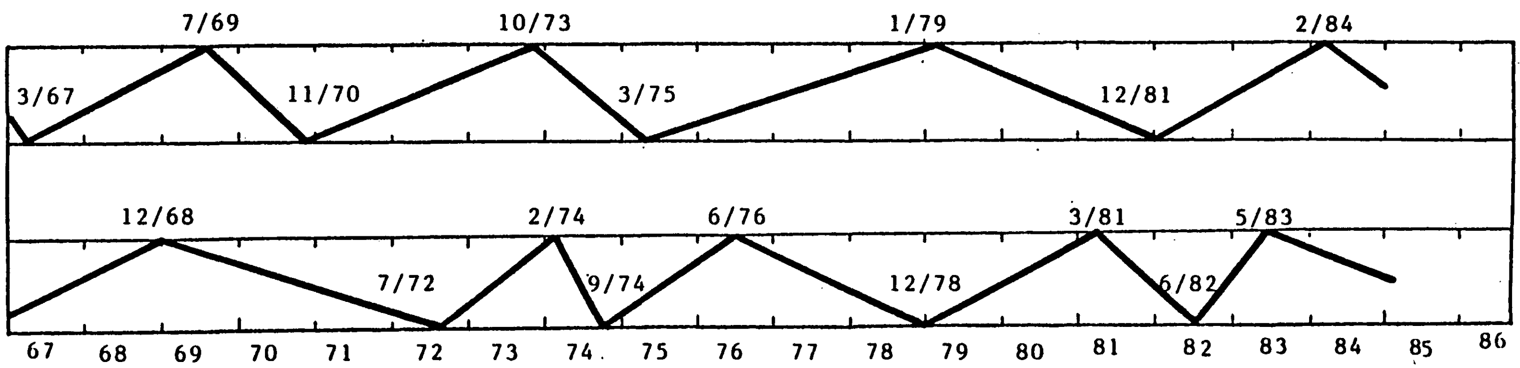
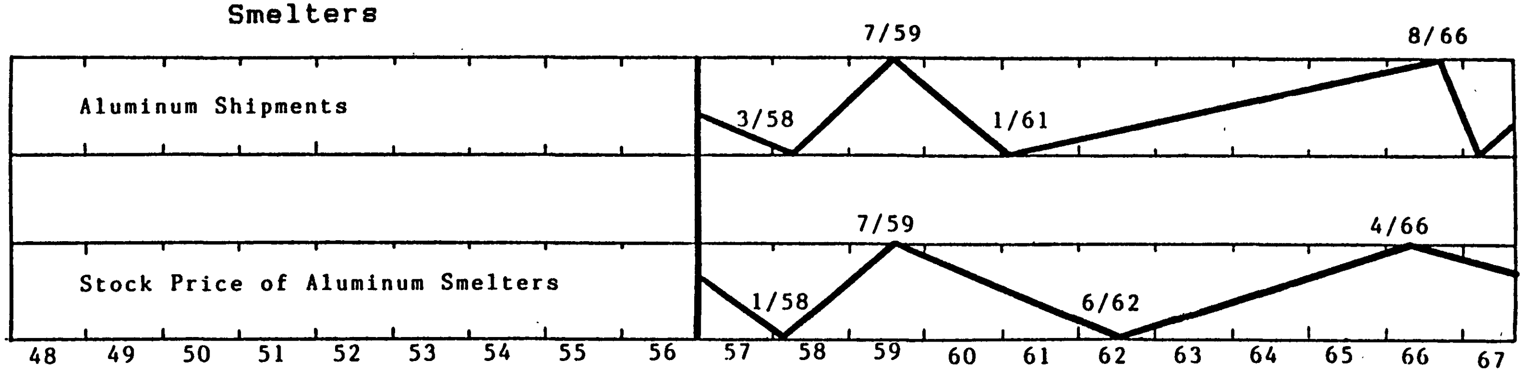
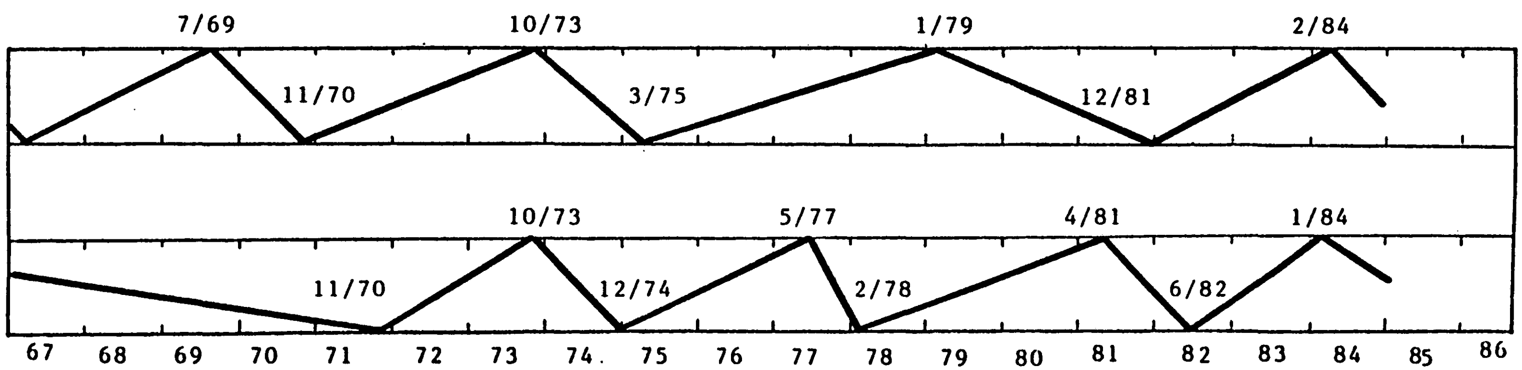


Chart 4-7 **Aluminum Shipments vis-a-vis Stock Price Index of Aluminum Smelters**



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS		7/59	8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)		0	-4	–	0	27	-1				6	1	2	1	2	1	0	4	13	1
TROUGHS	3/58	1/61	3/67	11/70	3/75	12/81														
L(-) or Lg(+)	-2	17	–	12	-3	6					6	1	2	2	0	3	6	6	9	1
P and T											12	2	4	3	2	4	0	5	10	2



Stock Price Index of Aluminum Smelters is more attributable to various economic activities in the general economy which also affect the movement of Aluminum Shipments in an indirect way. Furthermore, it can be said that with the capital intensive- ness of the aluminum industry, business activity is hardly influenced by random changes of stock prices. Table 4-4 shows performances of some other indicators compared to Aluminum Shipments.

4.4 Leading Indicator Analysis of Aluminum Scrap Prices

Twenty-one time series were investigated for the selection of leading indicators. Eight series were sorted out as leading indicators from those time series. Performances of those leading indicators are shown in Table 4-5. Performances of other time series that did not lead Aluminum Scrap Prices are shown in Table 4-6.

As mentioned earlier, among various prices in the primary and secondary aluminum industry, Scrap Price was selected as the subject of forecasting, for it leads free market Primary Ingot Prices such as Midwest Ingot Price and LME Ingot Price. Scrap Price of Aluminum is subject to free market principles. Besides that, the secondary industry is closely related to conditions in the primary aluminum industry. Scrap Price is more volatile than market-

Table 4-5 Leading Indicators for Aluminum Scrap Prices

Leading Indicators	Period Covered		Leads	Number of Coinci. Rough	Exact	Lags	Median Lead or Lag
Local Building Permits (SHSBP)	1/48 - 4/85	Peaks	8	1	0	0	-14
		Troughs	7	1	1	0	-8
		Total	15	2	1	0	-10
Monthly Sales of Cars (RCARD)	1/58 - 4/85	Peaks	4	1	0	2	-7
		Troughs	4	1	0	1	-12
		Total	8	2	0	3	-12
New Orders of Aluminum (CNEWS)	1/64 -12/84	Peaks	4	0	0	1	-8
		Troughs	4	1	0	0	-10
		Total	8	1	0	1	-8
Aluminum Stock Price Index (ALSTK)	1/48 - 2/85	Peaks	3	1	0	3	+2
		Troughs	5	2	0	0	-6
		Total	8	3	0	3	-3
Mobile Home Shipments (HMOB)	1/59 - 3/85	Peaks	5	0	0	0	-8
		Troughs	5	2	0	0	-9
		Total	10	2	0	0	-8
Leading Index of Infla. (INLD4)	1/48 - 4/85	Peaks	5	1	2	2	-7
		Troughs	6	4	1	1	-3
		Total	11	5	3	3	-4
Imports of Aluminum (ALIMP)	1/64 -12/84	Peaks	3	0	0	1	-16
		Troughs	3	2	0	1	-10
		Total	6	2	0	2	-16
Leading Index of Al. Scrap Prices (Y2LD1)	1/58 - 4/85	Peaks	5	1	0	1	-8
		Troughs	5	0	1	0	-10
		Total	10	1	1	1	-8
Leading Index of Al. Scrap Prices (A6LD1)	1/48 - 4/85	Peaks	6	2	0	2	-6
		Troughs	7	1	1	0	-8
		Total	13	3	1	2	-8

Table 4-6 Other Indicators of Aluminum Scrap Prices

Name of Indicator, Period Covered		Number of Leads	Coinci. Rough	Coinci. Exact	Lags	Median Lead or Lag in Months
Stock Price Index	P	4	2	0	5	+6
Nonferrous Metal	T	6	1	0	2	-5
(48-84)	Tot.	10	3	0	7	-2
Midwest Price,	P	2	1	0	1	-1
Al Ingot	T	1	0	0	2	+9
(72-84)	Tot.	3	1	0	3	+2
Inventory Change	P	0	0	0	2	+10
Producers' Al	T	0	0	0	3	+15
(72-84)	Tot.	0	0	0	5	+10
Growth Rate of	P	2	1	0	1	-1
Earnings	T	0	0	0	2	+12
(64-84)	Tot.	0	2	2	5	+9
All Employees	P	0	0	2	2	+9
Numbers	T	0	2	0	3	+3
(64-84)	Tot.	0	2	2	5	+8
Nos., Production	P	1	1	1	2	+4
Workers	T	0	2	0	3	+3
(64-84)	Tot.	1	3	1	5	+3
Al Ingot Produc-	P	2	2	1	3	+4
tion	T	3	2	1	2	-2
(48-84)	Tot.	5	5	4	2	+5
Hours Worked	P	1	0	1	1	0
Weekly	T	2	1	1	1	-3
(64-84)	Tot.	3	1	2	2	0
Weekly Overtime	P	2	1	1	0	-1
Hours	T	1	2	0	1	0
(72-84)	Tot.	3	3	1	1	-1
Al Imports	P	3	0	0	1	-16
(64-84)	T	3	2	0	1	-10
	Tot.	6	2	0	2	-16

Table 4-6 (Continued)

Name of Indicator, Period Covered		Number of Leads	Coinci. Rough	Coinci. Exact	Lags	Median Lead or Lag in Months
Al Exports	P	1	0	0	2	+5
(64-84)	T	1	1	1	1	0
	Tot.	2	1	1	3	-2
Net Imports of	P	2	0	0	2	-5
Aluminum	T	3	3	0	1	-2
(64-84)	Tot.	5	3	0	3	-2
Growth Rate, Al	P	7	1	1	0	-8
Scrap Price	T	6	2	2	0	-4
(49-85)	Tot.	13	3	3	0	-7
Al Shipments	P	5	2	0	1	-4
(57-85)	T	5	0	1	0	-10
	Tot.	10	2	1	1	-6

controlled Ingot Prices. This means that Scrap Price reflects conditions in the market more actively than Ingot Prices. Compared to Ingot Prices, Scrap Price, starting from 1948, has more data. Therefore, Scrap Price was considered the representative price in the aluminum industry. It was assumed that Scrap Price had a certain economic relationship with the time series that were compared to it.

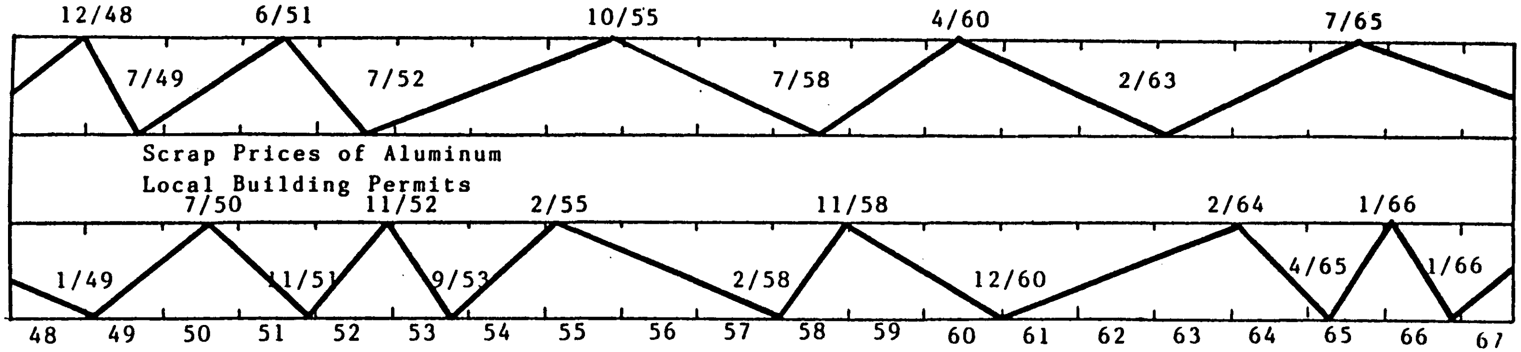
4.4.1 Local Building Permits

Local Building Permits was introduced as a candidate for a leading indicator. During the time period 1948-84 there were seventeen observations of turns in Cast Aluminum Scrap Price Index. Turns in Local Building Permits matched well with those in Scrap Price Index, with a certain range of intervals. There were six extra turns in the Building Permits. A turn of the Scrap Price Index in December 1948 was skipped by Building Permits because data of Building Permits started in 1948, thus missing the matching turn. In the peak-to-peak comparison, Building Permits had seven leads and one coincidency. In the trough-to-trough comparison, Building Permits had seven leads and two coincidencies. As a whole, there were fourteen leads and three coincidencies by Building Permits. The median lead was eight months. Building Permits had fifteen leads out of sixteen observations of turning points, an excellent performance. It can be said that Building Permits is a perfect leading indicator of the Scrap Price Index. The only problem is that Building Permits had some extra turns. Most extra turns are from minor cycles. Extra cycles in Building Permits are as follows:

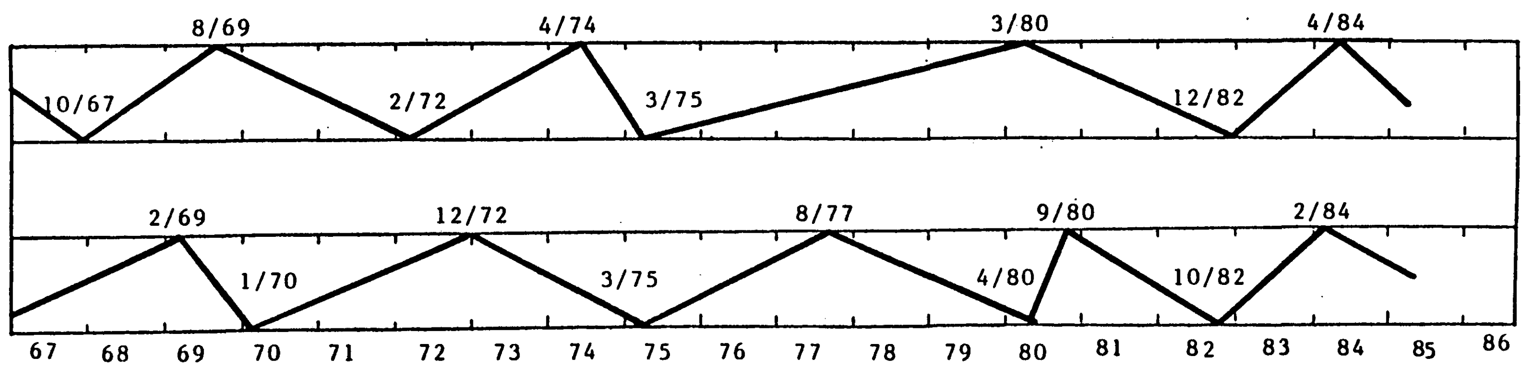
	Peak Date	Trough Date
First cycle	November 1952	September 1953
Second cycle	February 1964	April 1965
Third cycle	August 1977	April 1980

Whenever there is a turn in Building Permits, a turn in the Scrap Price Index can be expected. The increase of Building Permits means there will be an increasing need for construction materials such as fabricated aluminum. When the demand for fabricated aluminum from the secondary industry rises, the price of scrap aluminum must go up unless there is enough supply of that material. Chart 4-8 shows good performance of the Building Permits as a leading indicator of Aluminum Scrap Price Index.

Chart 4-8 Scrap Prices of Aluminum vis-a-vis Local Building Permits



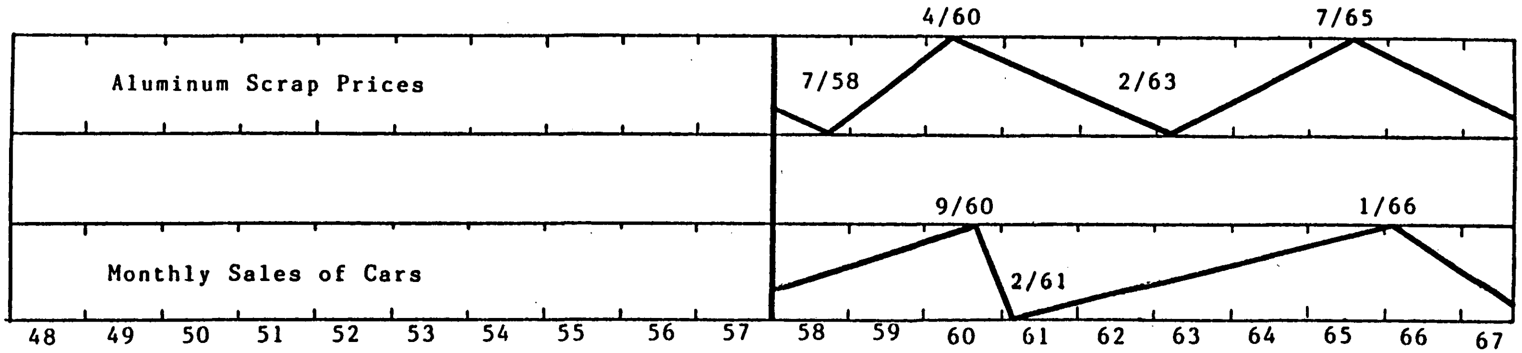
											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS	12/48	6/51	10/55	4/60	7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-)or Lg(+)	-	-11	-8	-17	6	-6	-16	-31	-2		9	1	7	1	0	1	-10	-11	11	3
TROUGHS	7/49	7/52	7/58	2/63	10/67	2/72	3/75	12/82												
L(-) orLg(+)	-6	-8	-5	-26	-11	-25	0	-2			8	0	7	1	1	0	-7	-10	10	3
P and T											17	1	14	2	1	1	-8	-11	10	6



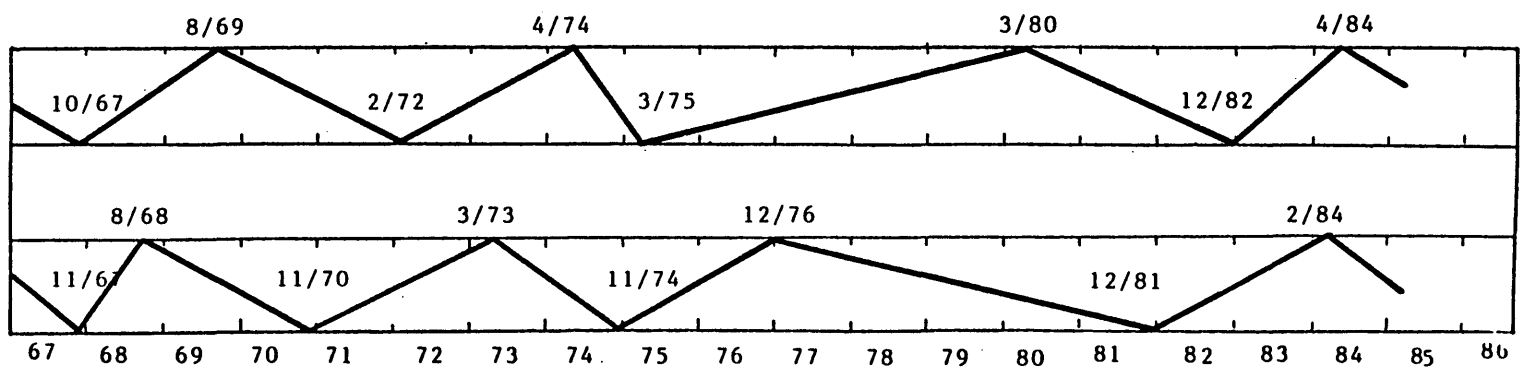
4.4.2 Monthly Sales of Cars (RCARD)

This time series has rougher outcomes than Building Permits. In fact, Sales of Cars is thought to be a better leading indicator of the Scrap Price Index because the car industry absorbs the secondary aluminum material more directly. There were twelve observations of turns with one skipped turn in the Scrap Price Index. There was no extra turn in Sales of Cars. Among eleven turns in Sales of Cars that were compared with the Scrap Price Index, eight were leading and three were lagging. There were two coincidencies. Lagging turns occurred in the early part of the time series, before 1968. After that year all the turning points of Sales of Cars were leading those of the Scrap Price Index. Therefore, there might have been some change in the pattern of aluminum demand in the car industry. The 39 months' lead in December 1976 by Car Sales is hard to accept. The price rise of scrap aluminum for 39 months since the downturn of Car Sales should be due to some other factors, such as oil price rise and increased demand in other sectors of the economy. Regardless of the irregular pattern of leads by turns of Sales of Cars, it was selected as a leading indicator. Chart 4-9 shows its performance.

Chart 4-9 Scrap Prices of Aluminum vis-a-vis Monthly Sales of Cars



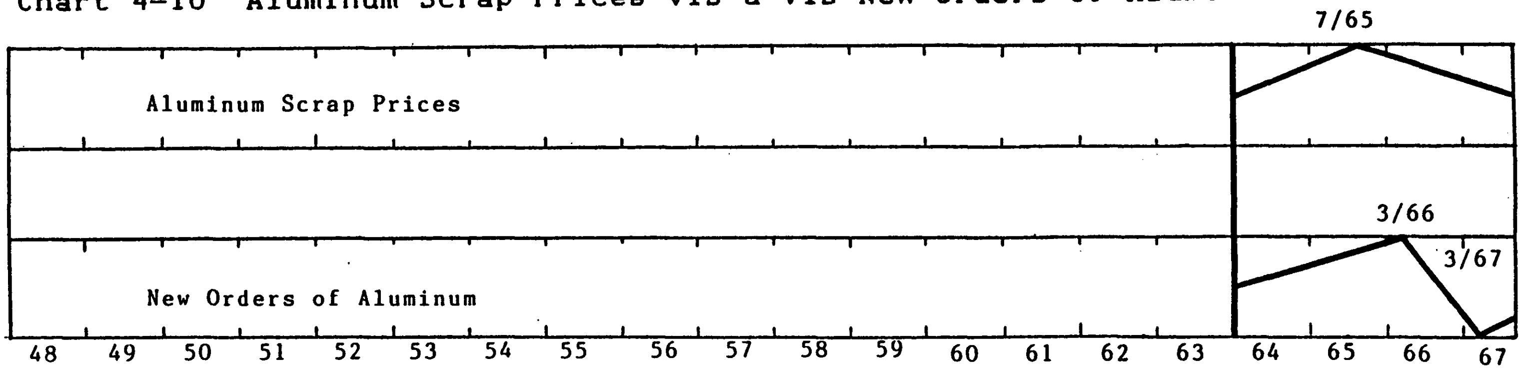
											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS				4/60	7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	lg(+)	Md	Mn		
L(-)or Lg(+)				5	6	-12	-13	-39	-2		6	0	4	1	0	2	-7	-9	17	0
TROUGHS			7/58	2/63	10/67	2/72	3/75	12/82												
L(-) orLg(+)			-	-24	1	-15	-4	-12			6	1	4	1	0	1	-12	-11	10	0
P and T											12	1	8	2	0	3	-12	-10	14	0



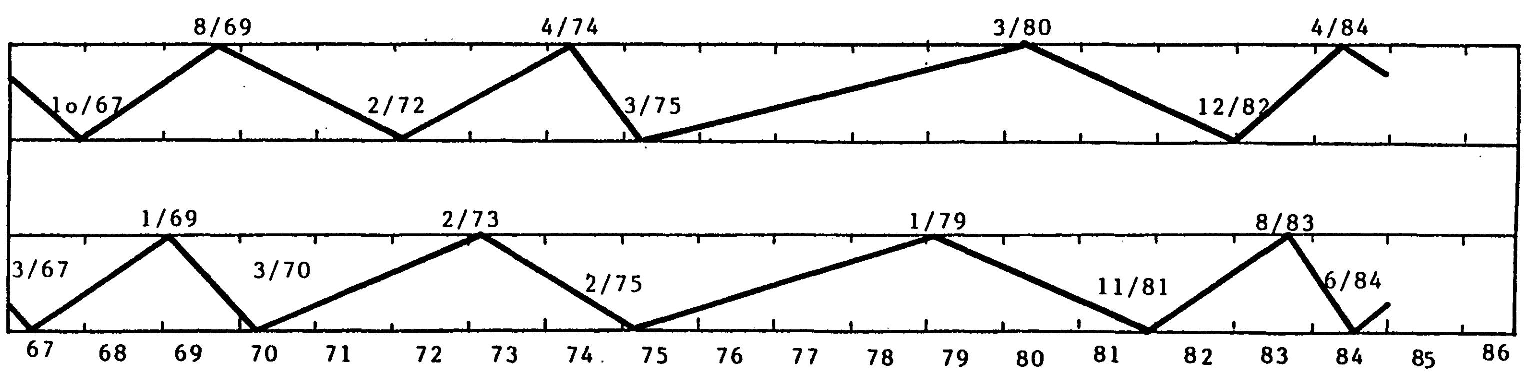
4.4.3 New Orders of Aluminum

New Orders of Aluminum was also selected as a leading indicator of Scrap Price Index of Aluminum. Out of nine turns in New Orders comparable with those of the Scrap Price Index, eight were leading and only one was lagging. The lagging turn of New Orders was in March 1966, as shown in Chart 4-10. After that lagging turn, turns of New Orders made very obvious leads of more than seven months for each lead, except a coincidency of a one-month lead in February 1975. New Orders had one extra turn in the 1964-84 time period covered. Chart 4-10 shows that, in general, the Scrap Price Index peaks during the downturn of New Orders and hits bottom during the upturn of New Orders. The delivery of New Orders may peak during the downturn of New Orders giving pressure to the supply of scrap, which, in turn, may raise the price of aluminum scrap. By the same reasoning, when New Orders is in its upturn--thus at some point realizing the delivery at the smallest amount-the scrap market will have surplus of supply and the scrap price may have to drop to the bottom. However, as New Orders by fabricators is mostly composed of primary ingot, the structure of the scrap price change may not be as simple as described above.

Chart 4-10 Aluminum Scrap Prices vis-a-vis New Orders of Aluminum



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS					7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-)or Lg(+)					8	-7	-14	-14	-8		5	0	4	0	0	1	-8	-7	9	0
TROUGHS					10/67	2/72	3/75	12/82												
L(-) orLg(+)					-7	-23	-1	-13			4	0	4	1	0	0	-10	-11	9	1
P and T											9	0	8	1	0	1	-8	-9	9	1



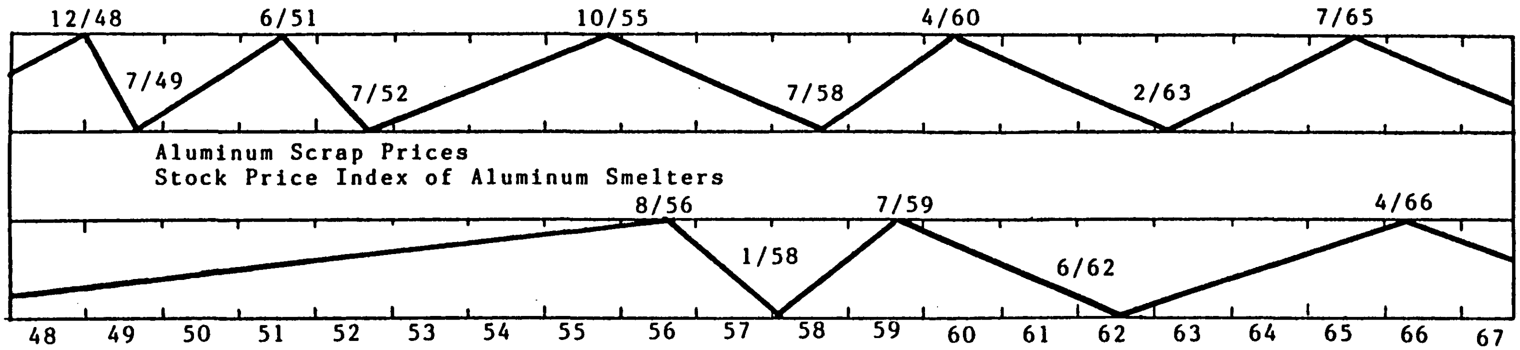
4.4.4 Composite Stock Price Index of Aluminum Smelters

Chart 4-11 shows some unstable statistics of the Composite Stock Price Index of aluminum smeltering companies as a leading indicator of the Aluminum Scrap Price Index. The Stock Price Composite is a composite index of stock prices of major aluminum smelters such as Alcoa, Alcan, Reynolds Metals, and Kaiser Aluminum. The Stock Price Composite was somewhat consistently leading at its troughs with a median lead of six months, whereas at its peaks it had three leads and three lags. Besides that, there were six turns in the Scrap Price Index skipped by the Stock Price Composite which had two extra turns in 1977-78. In general, the Stock Price Composite had eight leads, three lags, and two coincidencies. It was applied as a component of the Composite Leading Index of Aluminum Scrap Price Index, but soon was discarded because of its unstable record of leads.

4.4.5 Mobile Home Shipments (HMOB)

As shown in Chart 4-12, Mobile Home Shipments was leading at every turn whenever the comparison of turns with the Scrap Price Index was available. It had two minor extra cycles which were not repeated in the Scrap Price Index. The median of leads was eight months. It was included as a

Chart 4-11 Aluminum Scrap Prices vis-a-vis Stock Price Index of Aluminum Smelters



										No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS	12/48	6/51	10/55	4/60	7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)	–	–	10	-9	9	–	-6	7	-3		9	3	3	1	0	3	2	1	8	1
TROUGHS	7/49	7/52	7/58	2/63	10/67	2/72	3/75	12/82												
L(-) or Lg(+)	–	–	-6	-8	–	-3	-3	-6			8	3	5	2	0	0	-6	-5	2	1
P and T											17	6	8	3	0	3	-3	-2	7	2

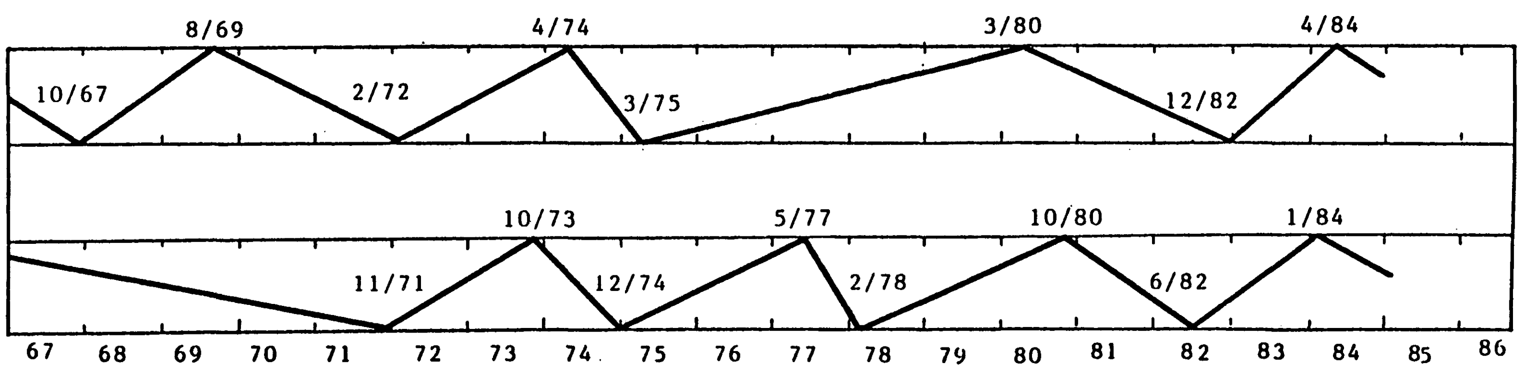
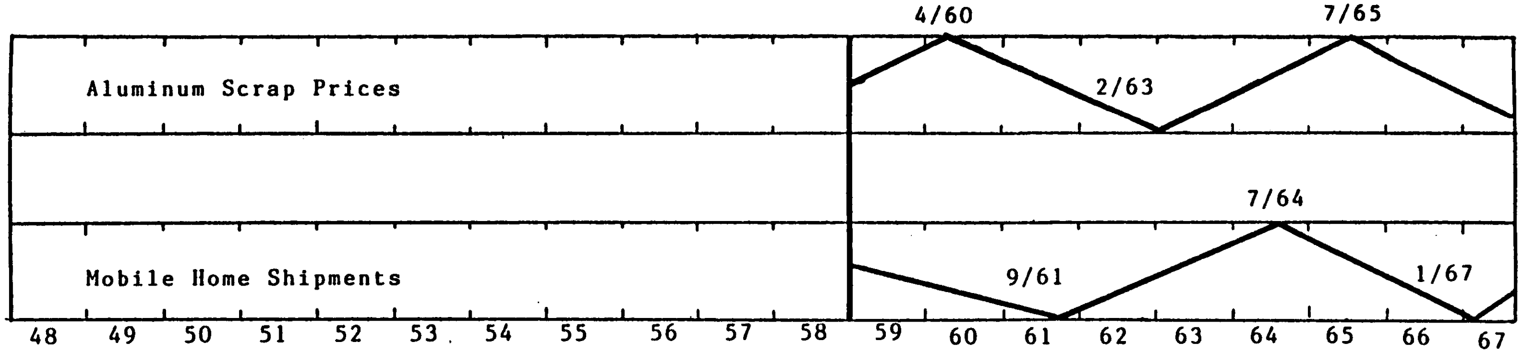
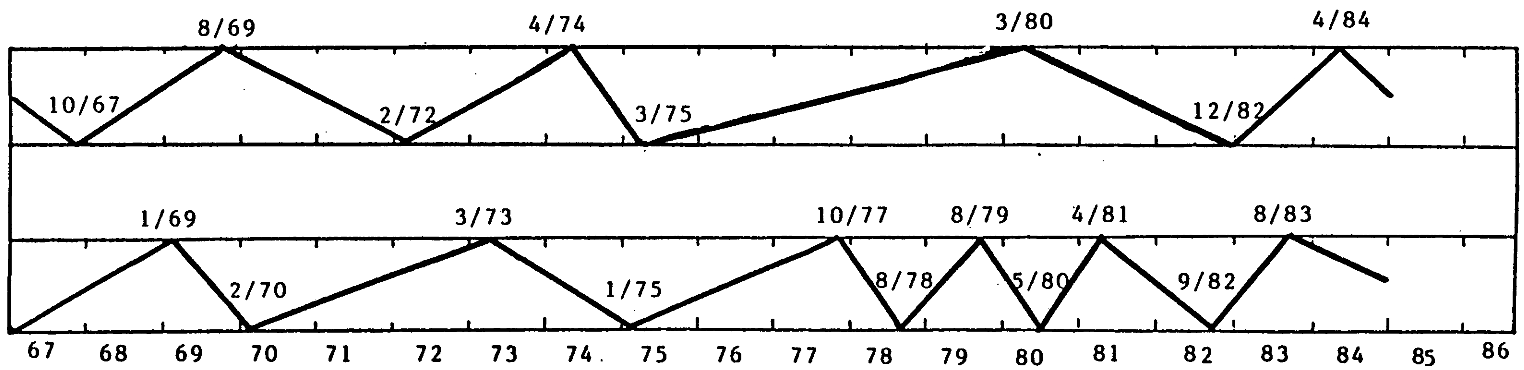


Chart 4-12 Aluminum Scrap Prices vis-a-vis Mobile Home Shipments



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS				4/60	7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)				-	-12	-7	-13	-7	-8		6	1	5	0	0	0	-8	-9	3	2
TROUGHS				2/63	10/67	2/72	3/75	12/82												
L(-) or Lg(+)				-17	-9	-24	-2	-3			5	0	5	2	0	0	-9	-11	9	2
P and T											11	1	10	2	0	0	-8	-10	7	4

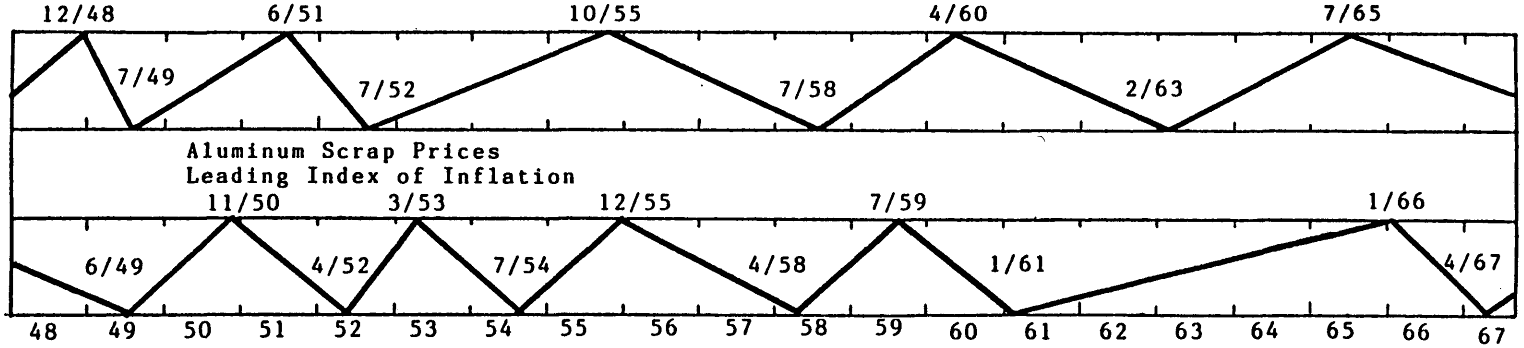


component for the composite leading index of Aluminum Scrap Prices.

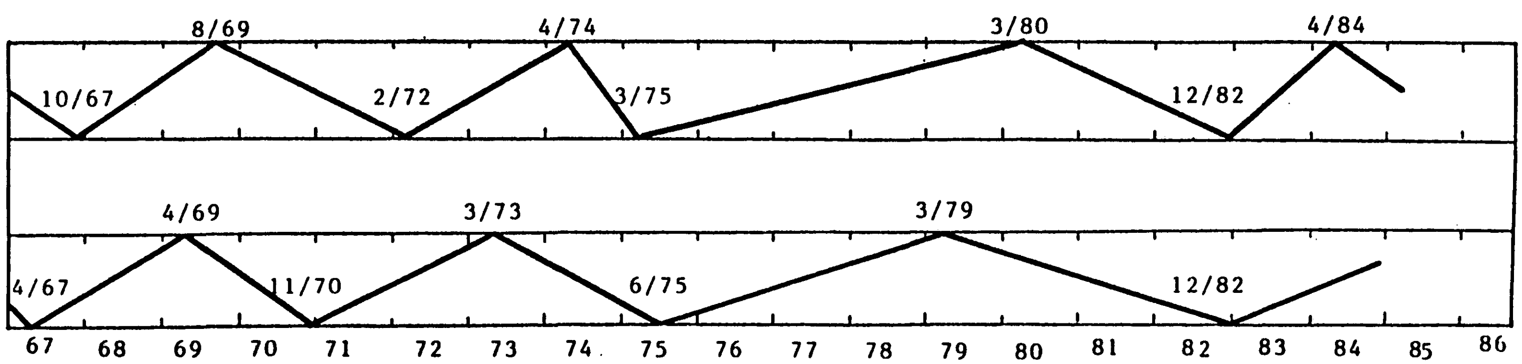
4.4.6 Leading Index of Inflation

Leading Index of Inflation had eleven leads, three lags, and six coincidencies. The size of lags was less than six months. On the other hand, the size of leads spread widely from one month to 25 months. There was one minor cycle in the Leading Index in 1952-53 which was ignored in Aluminum Scrap Prices but was reflected in Clipping Price of Aluminum, which is a coincident indicator of Aluminum Scrap Prices. In fact, around that time period, Aluminum Scrap Prices had a very small cycle which was not important enough to be labeled as a regular cycle. Because Aluminum Scrap Prices is one component of the Wholesale Price Index in the economy, it is expected that the Leading Index leads it at turns. Only on three occasions did the turn of Aluminum Scrap Prices come earlier than those of the Leading Index. Therefore, Leading Index of Inflation was used as a leading indicator. Chart 4-13 shows the result of the comparison.

Chart 4-13 Aluminum Scrap Prices vis-a-vis Leading Index of Inflation



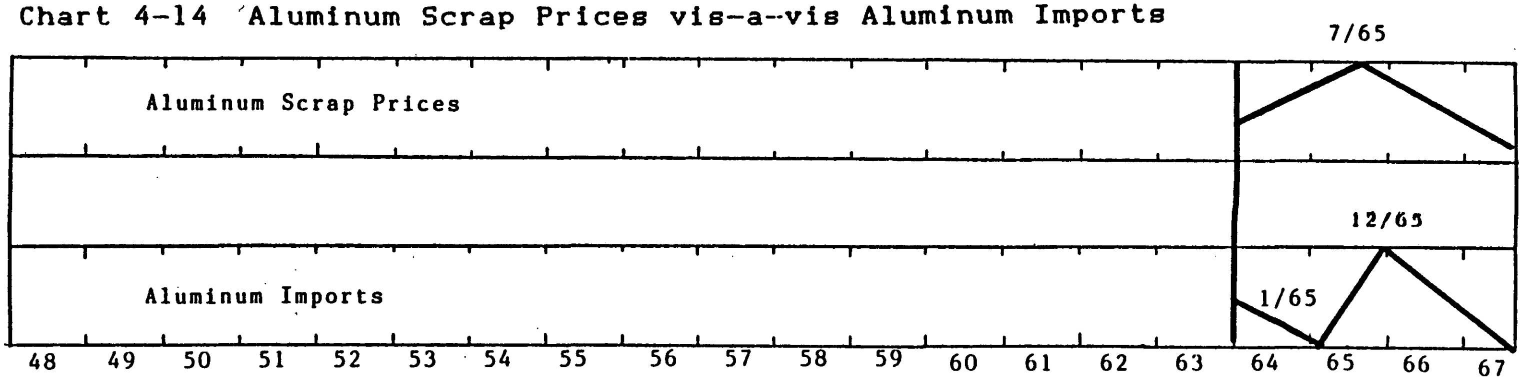
											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS	12/48	6/51	10/55	4/60	7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)	—	-7	2	-9	6	-4	-13	-12	—		9	2	5	1	0	2	-7	-5	7	1
TROUGHS	7/49	7/52	7/58	2/63	10/67	2/72	3/75	12/82												
L(-) or Lg(+)	-1	-3	-3	-25	-6	-15	3	0			8	0	6	4	1	1	-3	-6	9	1
P and T											7	2	11	5	1	3	-4	-6	8	2



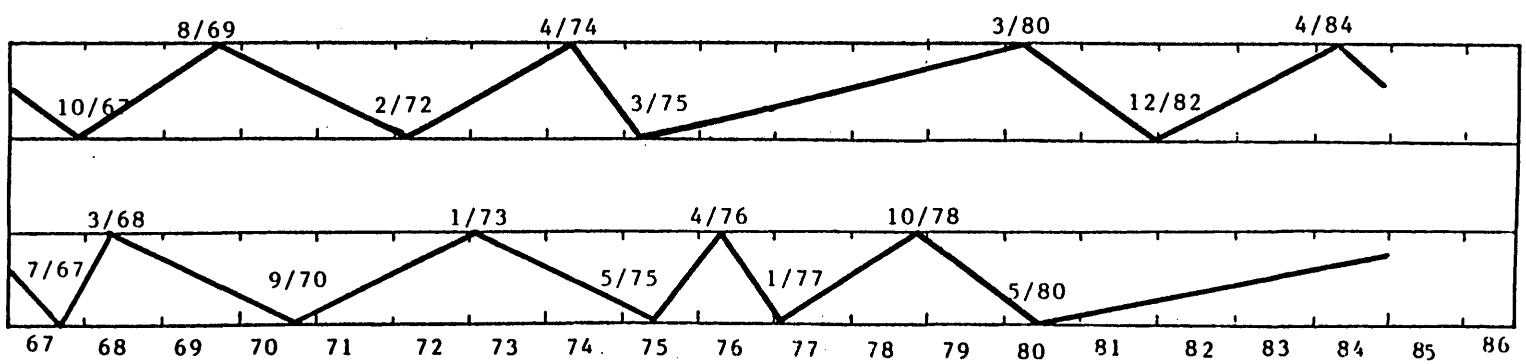
4.4.7 Aluminum Imports (ALIMP)

As Chart 4-14 shows, Aluminum Imports had six leads, two lags, and two coincidencies at its turns when it was compared with Aluminum Scrap Prices. Aluminum Imports had two extra turns in the 1976-77 time period. The size of each lead by turns of Aluminum Imports varied from three months to 31 months, thus lacking consistency. Aluminum is imported in a finished form. Therefore, it does not have a direct relationship to the domestic scrap market. However, the level of the imports certainly reflects the condition of the U.S. aluminum industry and its market. Aluminum Imports might increase when the U.S. dollar is stronger than the currencies of countries which produce aluminum products or when imported products of aluminum are cheaper than those produced in the United States. Then, the increased amount of the imported aluminum may reduce the domestic supply of new scrap. It would take a long time for imported aluminum products to be recycled as scrap. Therefore, imported aluminum products do not affect the current supply of aluminum scrap directly, but affect it indirectly by controlling the amount of new scrap produced by the domestic aluminum industry. The price of aluminum scrap might have to go up when imports increase. Nonetheless, there is no obvious relationship between

Chart 4-14 Aluminum Scrap Prices vis-a-vis Aluminum Imports



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS					7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)					5	-17	-15	-17	—		5	1	3	0	0	1	-16	-11	10	1
TROUGHS					10/67	2/72	3/75	12/82												
L(-) or Lg(+)					-3	-17	2	-31			4	0	3	2	0	1	-10	-12	15	2
P and T											9	1	6	2	0	2	-16	-12	12	3



Imports of Aluminum and Aluminum Scrap Prices, probably because the amount of imported aluminum products is smaller than the amount of domestically produced aluminum.

4.4.8 Other Time Series in the Aluminum Industry

Various time series such as Employee Numbers in Primary Aluminum Industry and Ingot Production were also compared to Aluminum Scrap Prices. The result of the comparison was shown in Table 4-6. While most of the time series showed erratic relationships, some series such as Growth Rate of Scrap Prices and Aluminum Shipments turned out to be leading indicators of Aluminum Scrap Prices. Growth Rate of Scrap Prices is supposed to lead the Scrap Prices naturally. It had thirteen leading turns with six coincidencies. The length of the lead is usually dependent on the length of that particular cycle, unless there is an extra turn of the Growth Rate in the period of the corresponding cycle. That is why the Growth Rate is not included as a component of the leading index.

Aluminum Shipments led Aluminum Scrap Prices with ten leads and only one lag. However, there appears to be no direct relationship between these two series. In fact, Aluminum Shipments covers the scrap recovery.

Chapter 5

CONSTRUCTION OF COMPOSITE LEADING INDEXES

5.1 Standardization of Components and Indexes

To assist business cycle studies, the Bureau of Economic Analysis computes and publishes indexes of series which tend to lead, to nearly coincide with, and to lag the general economy. These indexes are generated with the use of the Indexes computer program. The CIBCR uses the same program to generate the Composite leading indexes. In following sections the program is explained (CIBCR n.d.).

A composite index is a single time series which reflects the aggregate performance of a group of time series, each of which may vary in unit of measurement, amplitude of variation, and level. There are five fundamental steps in computing such an index: 1) For each component series, symmetrical percentage changes are computed using the formula $200(X_{t+1} - X_t)/(X_{t+1} + X_t)$. 2) Each series of changes in step 1 is standardized, i.e., divided by a long-run trailing moving average of these changes without regard to sign. In computing the composite index of leading indicators a sixty month trailing moving average is used. For the first five years of any series, the component standardization factor is the average (without regard to sign), then it changes monthly thereafter. Standardization puts all the components on a equivalent ground (i.e., their average month-to-month change is 1.0) and prevents the more volatile series from prevailing the indexes. 3) For each month, a weighted average of the standardized changes in step 2 is computed. The sum of the weights equals the number of series in the index so that the divisor is the number of components. If data value is unavailable for a given month, the sum of those weights corresponding to available data values becomes the divisor. Step 2, in effect, gives each series the same weight. It is sometimes desirable to give more or less weight to different components. In computing the composites of leading, coincident, and lagging indicators, for example, the components are given weights proportional to the scores they acquired as cyclical indicators. The scores are determined by a series' economic significance, statistical adequacy, cyclical timing, conformity to business cycles, smoothness, and accuracy (Zarnowitz and Boschan 1977). The weight for a particular series is its score divided by the average score for all components of the given composite index. However, in generating composite leading indexes in this research, equal weights were given to each leading indicator. 4) The average changes from step 3 are also standardized (i.e., divided by their average without regard to sign). This standardization procedure makes the average month-to-month percentage change (without regard to sign) in the composite index equal to one and provides a useful standard by which to compare changes for any particular period. This index standardization factor is computed from January 1948 through December 1974 for the composite index of leading indicators. 5) The result of step 4 whose terms are, say, r_1, r_2, r_3,..., r_t, are cumulated on 100 with the formula 200 + r; e.g., January 1948 has the value of 100, February will have the value $100 \times \frac{200 + r_1}{200 - r_1}$, and March will have the value $100 \times \frac{200 + r_1}{200 - r_1} \times \frac{200 + r_2}{200 - r_2}$, etc. The index is then obtained by rebasing this series on 1967, i.e., dividing the series by the average of the values in 1967. It is sometimes desirable to match the trend of an index with the trend of another series. This is achieved in the indexes program by using the method of cycle averages. The trend of each of the two series is computed by finding, for each, the average value of the earliest specific business cycle (peak-to-peak) and the average value of the most recent specific cycle, centering each average in the middle of the cycle and applying the compound interest formula to the ratio of the latest to the earliest cycle averages. The difference between the two trends thus obtained is then added to the standardized average changes of step 4 and these modified changes are cumulated and rebased in step 5.

5.2 Formation of Composite Leading Indexes

In order to find the best leading index for Aluminum Shipments, six different indicators were sorted out as follows:

Name of Leading Indicators	Acronym
Local Building Permits	SHSBP
New Orders of Aluminum	CNEWS
Leading Index of U.S. Business	DLEAD
Mobile Home Shipments	HMOB
Monthly Sales of Cars	RCARD
Stock Price Composite of Non-Ferrous Metal Mining Industry	METALS

The performances of the above leading indicators to Aluminum Shipments are shown in Table 4-3 on p. 45. Based on these leading indicators, four different leading indexes were generated as follows:

Name of Leading Indexes	Components
A2LD1	SHSBP, CNEWS, DLEAD, RCARD
A3LD1	SHSBP, CNEWS, DLEAD, RCARD, HMOB
A5LD1	SHSBP, CNEWS, DLEAD, HMOB
X2LD1	SHSBP, CNEWS, DLEAD, HMOB, METALS

The leading index of aluminum (A5LD1) showed the best performance among these leading indexes. The leading index

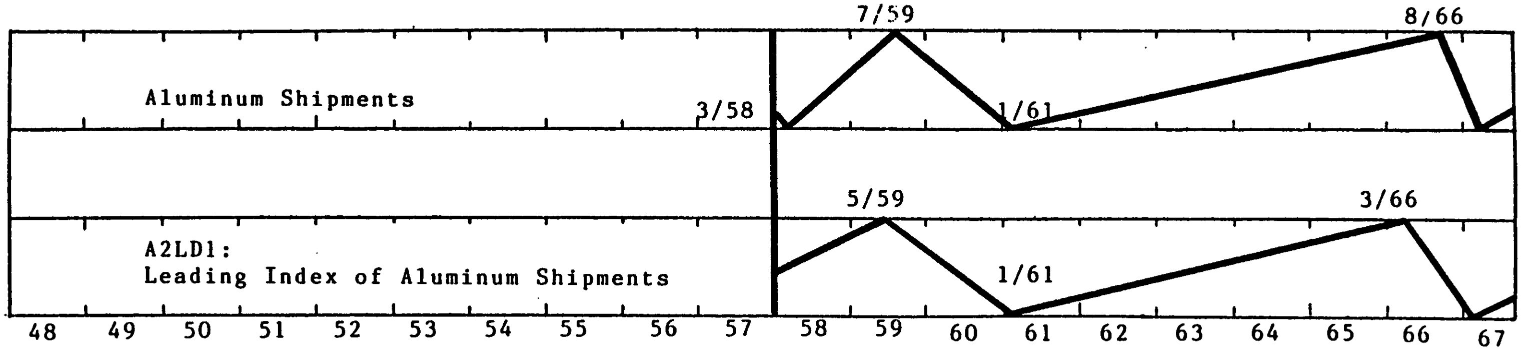
A5LD1 had eleven leads and seven coinsidencies with no lag. The median lead for peaks was four months. The median lead for troughs was two months. The performances of these indexes were shown in Table 4-3 and appear in Charts 5-1, 5-2, 5-3, and 5-4.

Through the same procedure, the best leading index for the aluminum scrap prices was sought. There were seven possible components for the leading indexes as follows:

Name of Leading Indicators	Acronym
Local Building Permits	SHSBP
Monthly Sales of Cars	RCARD
New Orders of Aluminum	CNEWS
Aluminum Stock Price Composite	ALSTK
Mobile Home Shipments	HMOB
Leading Index of Inflation	INLD4
Imports of Aluminum	ALIMP

From these leading indicators, two different leading indexes were generated: Y2LD1 had all the components, and A6LD1 had all the components except one leading indicator, ALSTK. From these two composite leading indexes, Y2LD1 was chosen as a better composite leading index than A6LD1. Y2LD1 had ten leads, one lag, and one coincidency, whereas A6LD1 had thirteen leads, two lags, and four coincidencies. In fact, these two composite leading indexes shared the same dates of turning points except at two occasions since 1958. These two occasions are related with two peak dates

Chart 5-1 Aluminum Shipments vis-a-vis A2LD1



											No. of Observ.	Skipped Turns	Number of L(-)	Number of ±3	Number of 0	Number of Lg(+)	L(-) or Lg(+) Md	L(-) or Lg(+) Mn	Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			7/59	8/66	7/69	10/73	1/79	2/84												
L(-) or Lg(+)			-2	-5	-6	-8	-9	0			6	0	5	1	1	0	-6	-5	3	0
TROUGHS		3/58	1/61	3/67	11/70	3/75	12/81													
L(-) or Lg(+)		-	0	-1	0	0	-1				6	1	2	2	3	0	0	0	1	0
P and T											12	1	7	3	4	0	-2	-3	3	0

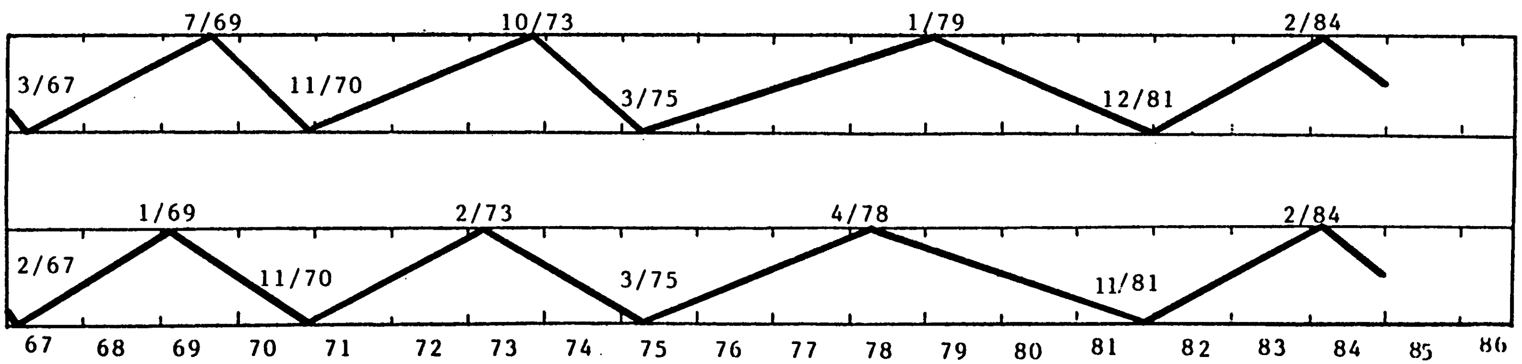
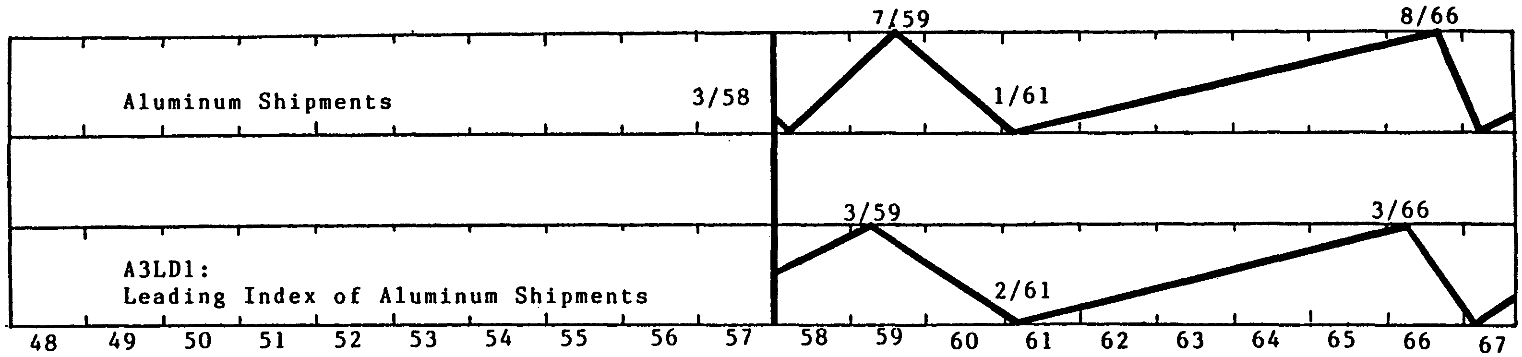


Chart 5-2 Aluminum Shipments vis-a-vis A3LD1



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			7/59	8/66	7/69	10/73	1/79	2/84					L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)			-4	-5	-6	-8	-7	0			6	0	5	0	1	0	-6	-5	3	0
TROUGHS		3/58	1/61	3/67	11/70	3/75	12/81													
L(-) or Lg(+)		-	+1	-1	-8	0	-1				6	1	3	3	1	1	-1	-2	4	0
P and T											12	1	8	3	2	1	-4	-4	3	0

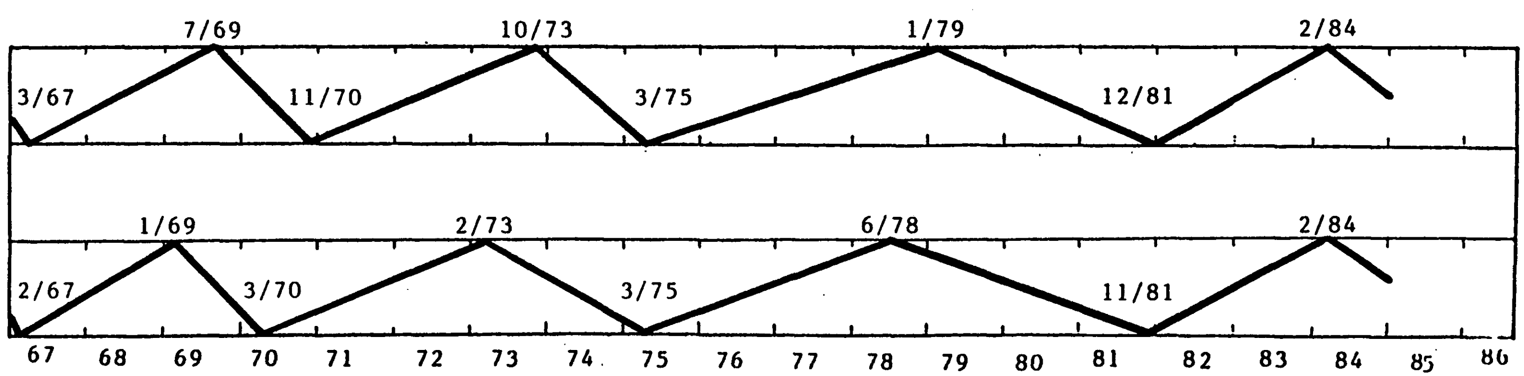
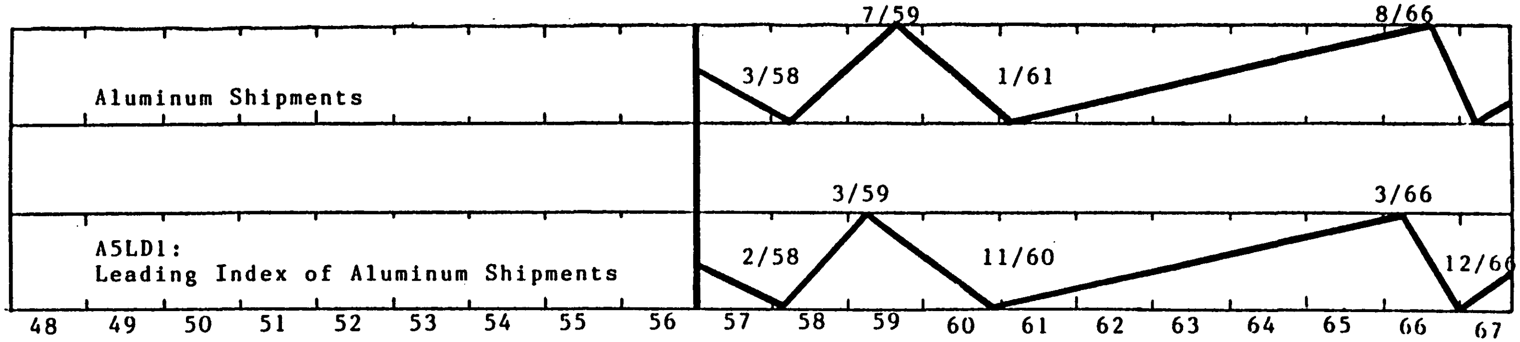


Chart 5-3 Aluminum Shipments vis-a-vis A5LD1



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			7/59	8/66	7/69	10/73	1/79	2/84					L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)			-4	-5	-6	-8	-1	-1			6	0	6	2	0	0	-4	-4	3	0
TROUGHS		3/58	1/61	3/67	11/70	3/75	12/81													
L(-) or Lg(+)		-1	-2	-3	-8	0	-1				6	0	5	4	1	0	-2	-3	3	0
P and T											12	0	11	6	1	0	-2	-3	3	0

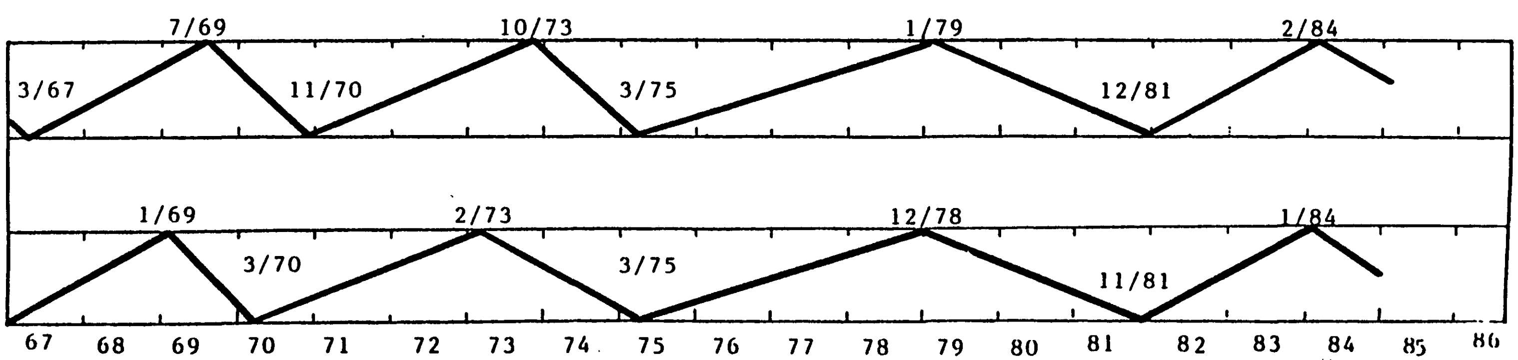
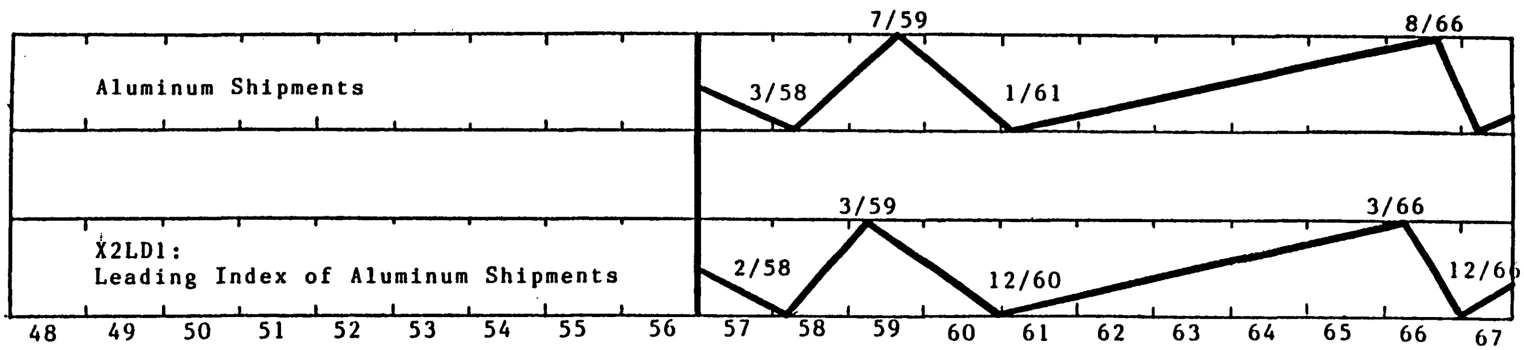
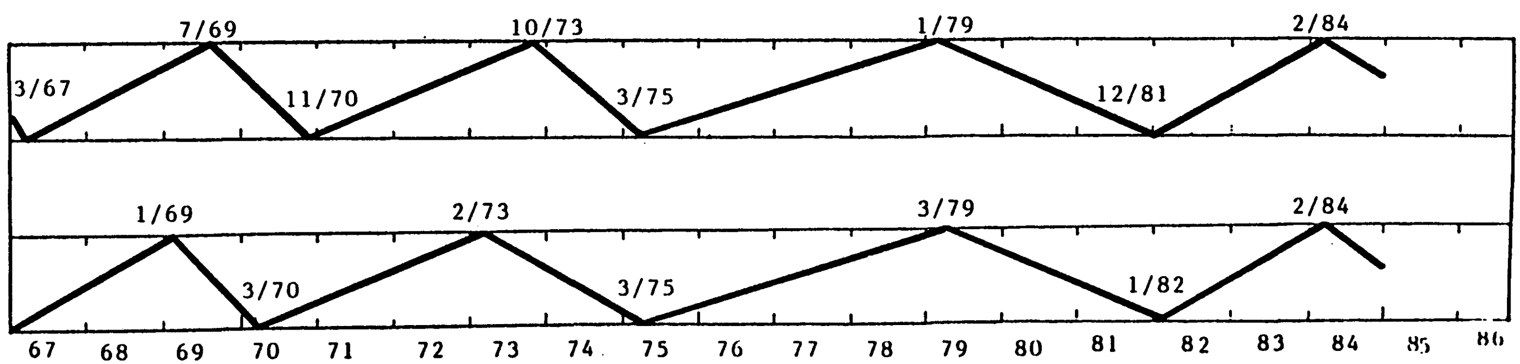


Chart 5-4 Aluminum Shipments vis-a-vis X2LD1



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
													L(-)	±3	0	Lg(+)	Md	Mn		
PEAKS			7/59	8/66	7/69	10/73	1/79	2/84												
L(-)or Lg(+)			-4	-5	-6	-8	+2	0			6	0	4	1	1	1	-4	-4	4	0
TROUGHS		3/58	1/61	3/67	11/70	3/75	12/81													
L(-) or Lg(+)		-1	+1	-3	-8	0	+1				6	0	3	4	1	2	0	-4	3	0
P and T											12	0	7	5	2	3	-2	-3	4	0



of Aluminum Scrap Prices in March 1980 and in April 1984. A6LD1 had a 21-month lead and a one-month lag respectively, and Y2LD1 had a 17-month lead and a three-month lead respectively. The performance of Y2LD1 was considered to be more consistent than that of A6LD1. The performances of these indexes were shown in Table 4-5 and appear in Charts 5-5 and 5-6.

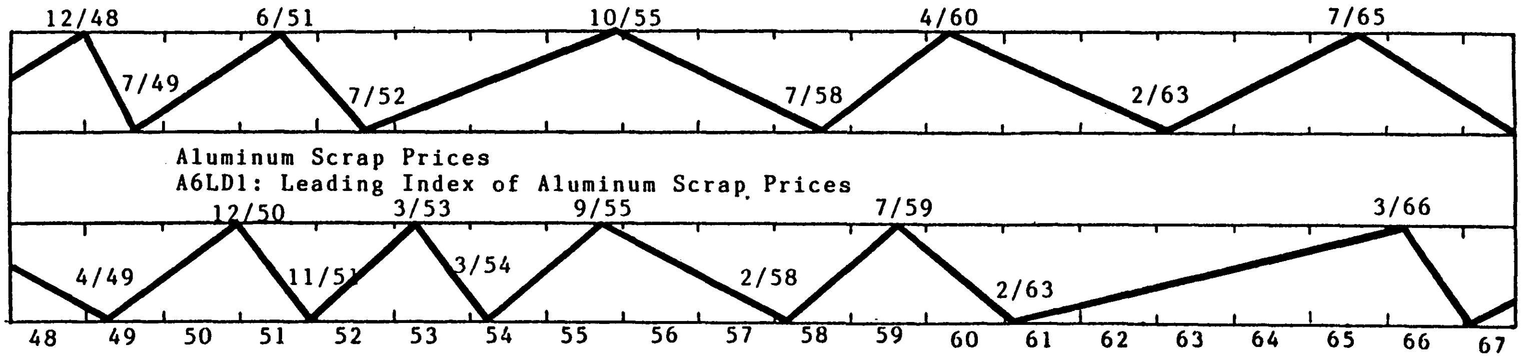
5.3 Sequential Signal Analysis

The sequential signal analysis is based on the previous result of the formation of two composite leading indexes. The purpose of this analysis is to find the signal dates of the foreseeable peak or trough of Aluminum Shipments and Aluminum Scrap Prices.

The process of this method consists of identifying certain signals from suitably smoothed rates of change in composite indexes of indicators, which normally occur in a predetermined sequence. The possibility of false alarms is reduced by using turning points first in the leading and then in the confirming indicators: Aluminum Shipments and Aluminum Scrap Prices (Zarnowitz and Moore 1982, 59).

Figure 5-1, in a hypothetical diagram, shows the smoothed rate of growth in the two series, which for simplicity will be called the "leading index rate" (L) and

Chart 5-5 Aluminum Scrap Prices vis-a-vis A6LD1



										No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS	12/48	6/51	10/55	4/60	7/65	8/69	4/74	3/80	3/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-)or Lg(+)	-	-6	-1	-9	+8	-7	-13	-21	+1		9	1	6	2	0	2	-6	-6	9	1
TROUGHS	7/49	7/52	7/58	2/63	10/67	2/72	3/75	12/82												
L(-) orLg(+)	-3	-8	-5	-24	-8	-15	0	-13			8	0	7	1	1	0	-8	-10	8	1
P and T											17	1	13	3	1	2	-8	-8	8	2

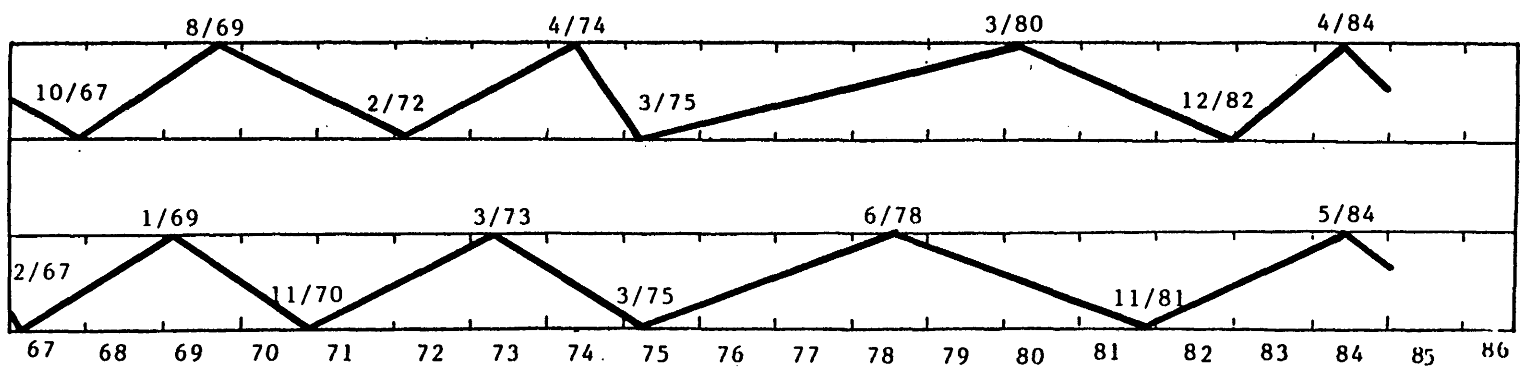
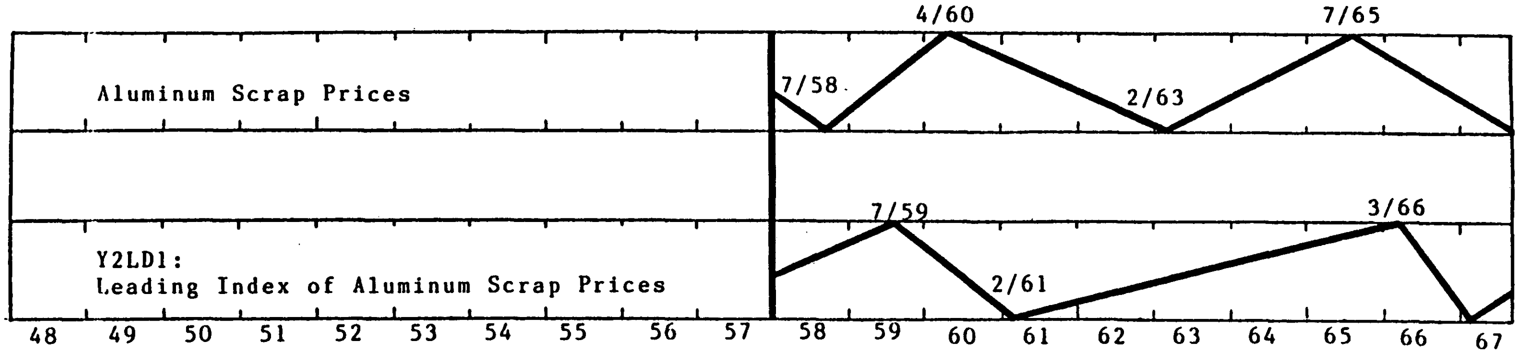


Chart 5-6 Aluminum Scrap Prices vis-a-vis Y2LD1



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS				4/60	7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-)or Lg(+)				-9	+8	-7	-13	-17	-3		6	0	5	1	0	1	-8	-7	9	0
TROUGHS			7/58	2/63	10/67	2/72	3/75	12/82												
L(-) or Lg(+)			-5	-24	-8	-15	0	-13			6	1	5	0	1	0	-10	-11	8	0
P and T											12	1	10	1	1	1	-8	-8	9	0

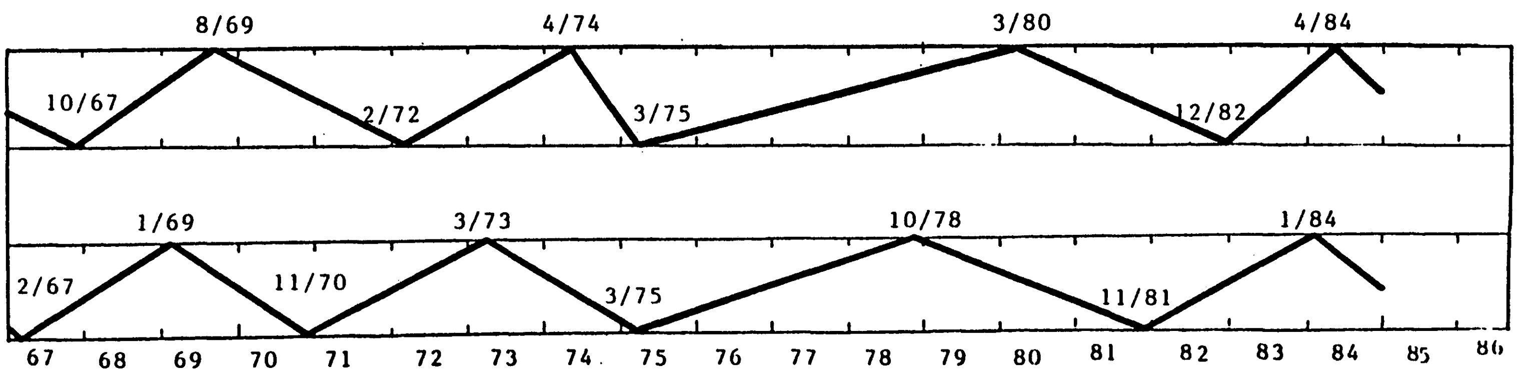
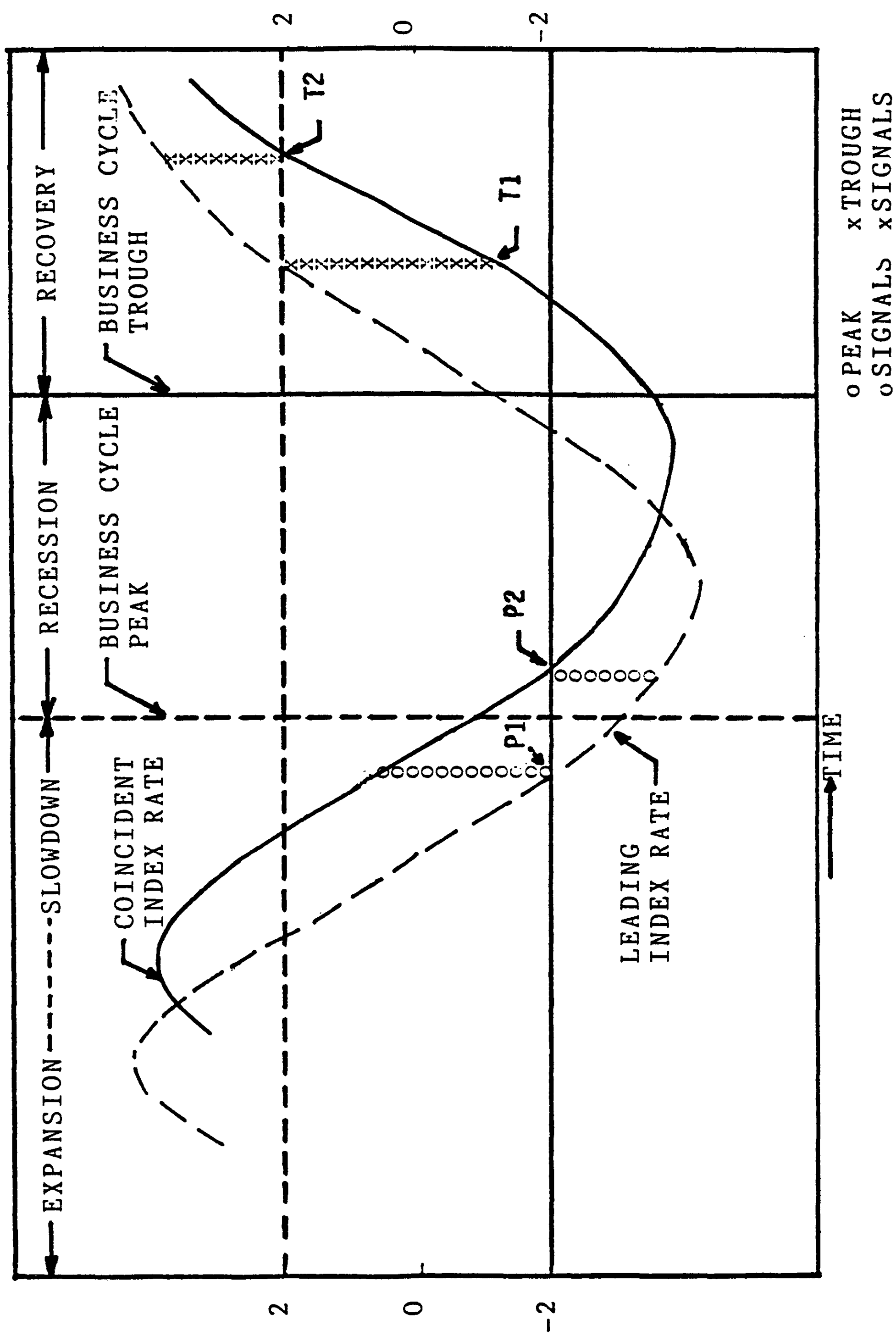


Figure 5-1 Sequential Signals of Recession and Recovery: A Schematic Diagram



the "coincident index rate" (C). The rates of growth actually used in this paper are smoothed 6-month changes and 12-month changes in annualized form. Those indexes contain much noise, i.e., short erratic movements, which do not appear in Figure 5-1. Twelve-month changes were used in the aluminum shipments cycle to avoid the noise even in 6-month changes. The expected sequence of signals at peaks and troughs of the aluminum shipments cycle and the aluminum scrap prices cycle occurs when each of the following conditions is first observed:

First signal of peak (P1): The leading index falls below -2%.
Second signal of peak (P2): The coincident index falls below -2%.
First signal of trough (T1): The leading index is above +2%.
Second signal of trough (T2): The coincident index rate is above +2%.

The cycle peak is expected to occur in the vicinity of P2, i.e., no more than a few months before or later than that signal. As shown in Table 5-1, the system produced three false warnings, August 1953, January 1954, and November 1961 when there was no recession of aluminum scrap prices to follow. The average lead of the first signal to the peak is one month and the average lag of the second signal to the peak is four months.

Table 5-2 shows that there were two false signals,

Table 5-1 Signals of Recession of Aluminum Scrap Prices: Timing at Cycle Peaks

Cycle Peak	First Signal(P1)	Second Signal(P2)	Lead(-) or Lag(+) First Signal	Lead(-) or Lag(+) Second Signal
12/48	-	3/49	-	+3
6/51	3/51	7/51	-3	+1
None	8/53	1/54	-	-
10/55	2/56	5/56	+4	+7
4/60	11/59	6/60	-5	+2
None	-	11/61	-	-
7/65	5/66	11/65	+10	+4
8/69	11/69	1/70	+3	+5
4/74	7/73	9/74	-9	+5
3/80	2/79	5/80	-13	+2
4/84	7/84	12/84	+3	+8
Average	---	---	-1	+4

Table 5-2 Signals of Recovery of Aluminum Scrap Prices: Timing at Cycle Troughs

Cycle Trough	First Signal(T1)	Second Signal(T2)	Lead(-) or Lag(+) First Signal	Lead(-) or Lag(+) Second Signal
7/49	8/49	2/50	+1	+7
7/52	6/52	2/53	-1	+7
None	9/54	4/54	-	-
7/58	7/58	11/58	0	+4
2/63	8/61	5/63	-18	+3
10/67	6/67	2/68	-4	+4
2/72	1/71	12/72	-13	+10
3/75	8/75	9/75	+5	+6
12/82	9/82	2/83	-3	+2
Average	---	---	-4	+5

April 1954 and in September 1954. The average lead of the first signals to the troughs was four months. The average lag of the second signals to the troughs was five months. The values of the lead or lag of the first signal to the trough were very rough, ranging from -18 to +5. However, based on the above two tables it can be said that the peak or trough of Aluminum Scrap Prices is located between months of the first and second signals.

If we study the signals of recession of Aluminum Shipments at cycle peaks we can find that, on average, both signals lagged the cycle peaks (see Table 5-3). Therefore, it can be said that Aluminum Shipments already had peaked out when the signal was dated. However, the three months' lag of the first signal can have a certain degree of meaning, for, generally, it is not easy to date the peak within six months without using the sequential signal analysis. Still, we can expect that the timing of the peak is just a few months after or before the first signal date.

The result of the analysis in Table 5-4 with signalling dates to troughs of aluminum shipments is more or less similar to that of the analysis to peaks of aluminum shipments. When we spotted the first signal, the trough would have passed three months before. It should be noted that there were no false warnings signalling the peak or

Table 5-3 Signals of Recession of Aluminum Shipments: Timing at Cycle Peaks

			Lead(-) or Lag(+)	
Cycle Peak	First Signal(P1)	Second Signal(P2)	First Signal	Second Signal
7/59	11/59	4/60	+4	+9
8/66	7/66	3/67	-1	+7
7/69	12/69	2/70	+3	+7
10/73	7/73	6/74	-3	+8
1/79	7/79	6/69	+6	+5
2/84	9/84	8/84	+7	+6
Average	---	---	+3	+6

Table 5-4 Signals of Recovery of Aluminum Shipments: Timing at Cycle Troughs

			Lead(-) or Lag(+)	
Cycle Trough	First Signal(T1)	Second Signal(T2)	First Signal	Second Signal
1/61	4/61	8/61	+3	+7
3/67	5/67	8/67	+2	+5
11/70	12/70	4/71	+1	+5
3/75	7/75	12/75	+4	+9
12/81	7/82	1/82	+7	+11
Average	---	---	+3	+7

trough of aluminum shipments. Strictly speaking, if the definition of signal is something that precedes the event, there is no way of knowing by the signalling method that the peak or trough is coming.

5.4 Statistical Tests on the Relationship of Shipments and Scrap Prices with Leading Indexes

The simple linear regression method was applied to gather more information about the relationship between the leading index and the subject time series. Regression equations in regard to several lags are shown in Tables 5-5 and 5-6. This part of the rersearch is new and different approach to the leading indicator analysis. It should be mentioned that the regression analysis of several time-lagged data after the construction of the composite leading index is a deviation from the main research. This work was intended to find positive results that could support the outcome of the research that the leading indexes lead the subject time series such as Aluminum Shipments and Aluminum Scrap Prices. However, the regression equations were not satisfactory in terms of that intention. In the regression of the Leading Index with Aluminum Shipments, the equations had high values of R squared. The highest value was 92.6 percent when the lag of

Table 5-5 Regression of Aluminum Shipments with its Leading Index

Lag	Equations	R^2(%)	S.D.	T-ratio
0	Y=-857+18.7X	90.6	.330	56.72
1	Y=-863+18.8X	91.6	.312	60.38
2	Y=-865+18.9X	92.3	.299	62.98
3	Y=-864+18.9X	92.6	.293	64.53
4	Y=-859+18.9X	92.6	.293	64.28
5	Y=-852+18.8X	92.5	.296	63.57
6	Y=-844+18.8X	92.2	.302	62.13
7	Y=-837+18.7X	91.8	.309	60.49

Where Y: estimated amount of aluminum shipments
X: value of Leading Index
S.D.: standard deviation of coefficient of X
T-ratio: T-ratio of coefficient of X

Table 5-6 Regression of Aluminum Scrap Prices with its Leading Index

Lag	Equations	R^2(%)	S.D.	T-ratio
0	Y=-16.1+.306X	14.5	.035	8.65
1	Y=-17.3+.319X	15.7	.035	9.06
2	Y=-18.1+.327X	16.4	.035	9.30
3	Y=-18.5+.332X	16.9	.035	9.44
4	Y=-18.7+.334X	17.1	.035	9.50
5	Y=-18.9+.336X	17.2	.035	9.53
6	Y=-18.8+.335X	17.1	.035	9.48
7	Y=-18.6+.334X	16.9	.035	9.39
8	Y=-18.3+.331X	16.5	.035	9.26
9	Y=-17.9+.326X	16.0	.036	9.07
10	Y=-17.3+.320X	15.3	.036	8.84
11	Y=-16.7+.314X	14.7	.036	8.61
12	Y=-16.1+.308X	14.1	.037	8.39

Where Y: estimated price of aluminum scrap
X: value of the Leading Index
S.D.: standard deviation of coefficient of X
T-ratio: T-ratio of coefficient of X

the data of the Leading Index was 3 months or 4 months. This is good coincidence with the 4 month median lead of the leading index in the turning points' comparison. In the regression of Aluminum Scrap Prices with its Leading Index, things were quite different. First of all, the values of R squared were generally very low, ranging from 14.1 percent to 17.2 percent. Even the highest value of 17.2 percent at the lag 5 cannot be very important because the Leading Index had 9 months lead in the turning points' comparison. Values of the standard deviation and T-ratio of the coefficient of X have been compared along the regression equations. Because these values were so closely distributed, it is very difficult to separate any one value. Therefore, it can be derived from the above results that the relationship of turning points in the Leading Indexes and the subject time series cannot be expanded to that of whole data points.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The main expectation of the leading index analysis is that if there were a peak (trough) in the recent data of the leading index, we can expect a peak (trough) in the subject cycle in the near future (probably with the time interval of the median lead of the leading index). This expectation is not, however, a certainty but only a probability shown by past experience. The exact timing of the subsequent turn is also not very reliable but does indicate the approximate amount of time to be on the lookout for a change. The trend of the leading index could be used to predict that of the subject cycle such as Aluminum Shipments or Aluminum Scrap Prices, no matter what the statistical significance is for that expectation. After all, this research is the first to apply that the leading indicator analysis to the U.S. aluminum industry.

The Leading Index of Aluminum Shipments, A5LD1, had eleven leads, one exact coincidency, and no lag. The median of leads was two months. The mean of leads was three months. The standard deviation of leads was three months. The Leading Index, A5LD1, was composed of Local Building

Permits, New Orders of Aluminum, Leading Index of U.S. Business, and Mobile Home Shipments. In the Sequential Signal Anaysis, on average, the first signal of peaks or troughs lags those turning points by three months.

The Leading Index of Aluminum Scrap Prices, Y2LD1, had ten leads, one exact coincidency, and one lag. The median and mean of leads were eight months. The standard deviation of leads was nine months. It should be pointed out that the size of the standard deviation is not very meaningful because we are dealing with less than eighteen sample points. The Leading Index, Y2LD1, was composed of Local Building Permits, Monthly Sales of Cars, New Orders of Aluminum, Stock Price Index of Aluminum Smelters, Mobile Home Shipments, Aluminum Imports, and Leading Index of Inflation. The other leading index, A6Ld1, had the same components, except for Stock Price Index of Aluminum Smelters. In the sequential signal analysis, the first signal of the peak had one-month lead, on average. The first signal of the trough had four months lead on average. Second signals of both peaks and troughs always lagged. The standard deviation of the lead of the first signal was eight months, which means we cannot expect the first signal to lead turning points all the time.

As shown in the regression analysis in Sec. 5.4, the fact that Leading Indexes lead the subject time series in turning points cannot be proved in the comparison of the whole data points. However, Leading Indexes created in this research were certainly meaningful even though they are not statistically reliable.

6.2 Recommendations

Three areas are recommended for further research of leading indicators in the U.S. aluminum industry.

First, Leading Indexes of Aluminum Shipmments and Scrap Prices could be revised and perhaps improved by using a different weighting system, for example, the scoring system of Zarnowitz and Boschan (1977). Their scoring system was not used in this study. Second, the Sequential Signal Analysis could be more fruitful if the signals were better defined. In the research some signals were found to lag turning points. This result could be improved by redefining signals. Third, the regression analysis might be meaningful if the multiple regression technique is applied against time-lagged data. It is the author's feeling that the simple regression analysis in this research gave some hint that the conclusion drawn from the relationship of turning points of Leading Index and the subject time series could be expanded to that of all data points.

REFERENCES CITED

Aluminum Association. 1985. Aluminum Statistical Review for 1984. Aluminum Association. Washington, D.C.

Bratt, Elmer C. 1961. Business Cycles and Forecasting. Homewood, Ill.: Richard D. Irwin, Inc.

Buell, Scot. 1985. "Leading Indicators of U.S. Oil and Gas Drilling Activity." M.S. Thesis. Colorado School of Mines, Golden, Colo.

Burns, Arthur F. and Wesley C. Mitchell. 1946. Measuring Business Cycles. NBER Studies in Business Cycles, No. 2. New York: NBER, Inc.

Eklund, Jr., Robert B. & Robert F. Hebert. 1975. A History of Economic Theory and Method. New York: McGraw-Hill, Inc.

Estey, James A. 1956. Business Cycles. Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Fisher, L.A. & A.D. Owen. 1981. "An Economic Model of the U.S. Aluminum Market." Resources Policy (September): 152.

Karfunkle, R.D. 1969. "Statistical Indicators of the Textile Cycle." Business Economics (May): 13-17.

Kaufmann, Thomas D. 1983. "Aluminum Industry Prospects, 1983-1993." Mineral & Energy Resources, vol. 26 (September). Colorado School of Mines, Golden, Colo.

Kinnard, W.N. 1979. "Business Cycle" in Encyclopedia Americana, Vol. 5: 45-48. Americana Corporation.

Kurtz, H.F. & L.H. Baumgardner. 1981. "Aluminum." Mineral Facts and Problems, 1980 Edition. BuMines Bull. 671: 9-34.

McCawley, Frank X & Luke. H. Baumgardner. 1981. "Aluminum." Mineral Facts and Problems, 1980 Edition. BuMines Bull. 671: 9-34.

McKenzie, Richard B. 1978. Modern Political Economy. New York: McGraw-Hill, Inc.

Metal Bulletin Monthly (London). 1984. The PIP Explained.

No. 162, (June): 101-107.

Moore, Geoffrey H. 1983. Business Cycles, Inflation, and Forecasting. NBER Studies in Business Cycle, No. 24. Cambridge, Mass: Ballinger Publishing Company.

_________. 1982. "Business Cycle" in Greenwald ed. Encyclopedia of Economics: 95-101. McGraw-Hill.

Moreland, Gary L. 1984. "Should Jamaica Lower the Bauxite Levy?" M.S. Thesis. Colorado School of Mines, Golden, Colo.

NARI. 1981. Recycling Aluminum. New York: National Association of Recycling Industry, Inc.

Peterson, G.R. & S.J. Arbelbide. 1983. Aluminum Availability-Market Economy Countries. IC 8917. BuMines Information Circular.

Schumpeter, Joseph A. 1939. Business Cycles-A Theoretical, Historical, and Statistical Anaysis of the Capitalist Process, vol. 1. New York: McGraw-Hill.

Slade, M.E. 1980. "The Effects of Higher Energy Prices and Declining Ore Quality: Copper-Aluminum Substitution and Recycling in the USA." Resources Policy (Guilford, Surrey, U.K.) (September): 228.

Stamper, J.W. & H.F. Kurtz. 1978. Aluminum. BuMines Min. Commodity Profiles: 29.

Valentine, Lloyd M. "Kondratieff Cycle" in Greenwald Ed. Encyclopedia of Economics: 579-581. New York: McGraw-Hill.

Woods, D.W. and J.C. Burrows. 1980. The World Aluminum Bauxite Market. A Charles River Associates Report. New York: Praeger Publishers.

Zarnowitz, Victor and Charlotte Boschan. 1977. "Cyclical Indicators: An Evaluation and New Leading Indexes." The Handbook of Cyclical Indicators. 170-174. Dep't of Commerce.

Zarnowitz, Victor and Geoffrey H. Moore. 1982. "Sequential Signals of Recession and Recovery." Journal of Business, vol. 55 (no. 1): 57-85.

ADDITIONAL READINGS

American Economic Association. 1944. Readings in Business Cycle Theory.

Banks, Ferdinand E. 1979a. Bauxite and Aluminum: An Introduction to the Economics of Nonfuel Minerals.

________. 1979b. "Short-run Price Formation in Non-fuel Mineral Markets." Resources Policy (December): 298-300.

Butler, W.F., Kavesh, R.A. & R.B. Platt. 1974. Methods and Techniques of Business Forecasting. New York: Prentice-Hall Inc.

Cunnyngham, Jon. 1965. Economic Forecasts, Forty-fifth Annual Report of the NBER (June): 60-64.

Daly, D.J. 1972. "Forecasting with Statistical Indicators" in Bert G. Hickman, ed., Econometric Models of Cyclical Behavior, Studies in Income and Wealth. No. 36, NBER and Social Science Research Council: 1159-83.

Fisher. L.A. and A.D. Owen. 1981. "An Economic Model of the U.S. Aluminum Market." Resources Policy (September): 150-160.

Frickey, Edwin B. 1942. Economic Fluctuations in the United States. Cambridge, Mass.

Granger, C.W.J. 1980. Forecasting in Business and Economics. New York: Academic Press.

Hymans, Saul H. 1973. "On the Use of Leading Indicator to Predict Cyclical Turning Points." Brookings Paper on Economic Activity, 2: 339-384.

Leibling, Herman I. 1972. "Comment on Daly, D.J.: Forecasting with Statistical Indicator," in Bert Hickman, ed., Econometric Model of Cyclical Behavior, Studies in Income and Wealth. No. 36, NBER and the Social Science Research Council.

McCawley, F.X. and L.H. Baumgardner. 1985. "Aluminum." Mineral Facts and Problems 1985 Edition. BuMines Preprint from Bulletin 675. U.S. Dept. of Interior.

McLeod, A.I. 1978. "On the Distribution of Residual Autocorrelations in Box-Jenkins Models." Journal of the Royal Royal Staistical Society, Series 13, 40 (No.3): 296-302.

Montgomery, D.C., and L.A. Johnson. 1976. Forecasting and Time Series Analysis. New York: McGraw-Hill.

Moore, Geoffrey H. 1975. "The Analysis of Economic Indicators". Scientific American (January): 17-23.

_________. 1961. Business Cycle Indicators, Vol. 1, Chapter 5, NBER.

_________. 1957. "Comment on 'Must the Diffusion Index Lead.'" American Statistician (October): 12-16.

_________. 1969a. "Forecasting Short-Term Economic Change." J. of Amer. Statis. Asso. 64 (March): 1-22.

_________. 1969b. "Generating Leading Indicators from Lagging Indicators." Western Economic Journal (June): 137-144.

Moore, G.H. and Shiskin, Julius. 1967. Indicators of Business Expansions and Contractions, Occasional paper 103. NBER.

Morris. Frank E. 1969. The Predictable Value of the National Bureau's Leading Indicators, Vol. 1, NBER: 110-119.

Okun, Arthur M. 1959. "Review of Some Economic Forecasts for 1955-57." Journal of Business (July).

Rendigs, Fels and C. Elton Hinshan. 1968. Forecasting and Recognizing Turning Points.

Rogers, Selwyn Phillips. 1978. "Economic Trends in the Aluminum Industry: Vulnerabilities and Options." Ph.D. diss. Colorado School of Mines, Golden, Colo.

Shiskin, Julius. 1970. "Economic Policy Indicators and Cyclical Turning Points." Business Economics (Sep.): 20-28.

_________. 1970. "the 1961 - 69 Expansions in the United

States." Business Conditions Digest (January).

_________. 1961. "Signals of Recession and Recovery." Occasional Paper 77 (Oct.). New York: NBER.

Shiskin, Julius and G.H. Moore. 1968. "Composite Indexes of Leading, Coincident, and Lagging Indicators, 1948-67." Supplement to National Bureau Report, 1. January. NewYork: NBER.

Skea, J. 1980. "Electricity Supplies for the Primary Aluminum Industry." Resources Policy (March): 60-70.

Stekler, H.O. 1961. "Diffusion Index and First Difference Forecasting." Review of Economics and Statistics 43 (May): 201-8.

_________. 1959. "Forecasting Industrial Production - Leading Series vs Autoregression." Journal of Political Economy 67 (No. 4, August): 402-9.

Suits, Daniel B. 1962. "Forecasting and Analysis with an Economic Model." American Economic Review, March.

U.S. Department of Commerce. 1977. Handbook of Cyclical Indicators.

Valvanis, Stefan. 1957. "Must the Diffusion Index Lead?" American Statistician (Oct.): 12-16.

APPENDIX A

CHARTS OF OTHER INDICATORS

A-1 Other Indicators of Aluminum Shipments

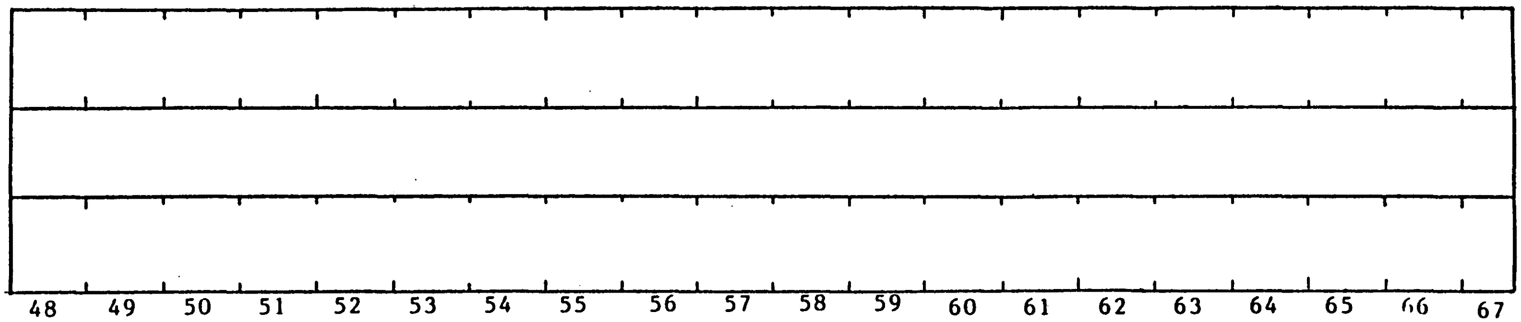
Some other indicators that were not chosen as leading indicators of Aluminum Shipments are discussed here.

A-1-1 Midwest Price of Aluminum Ingot

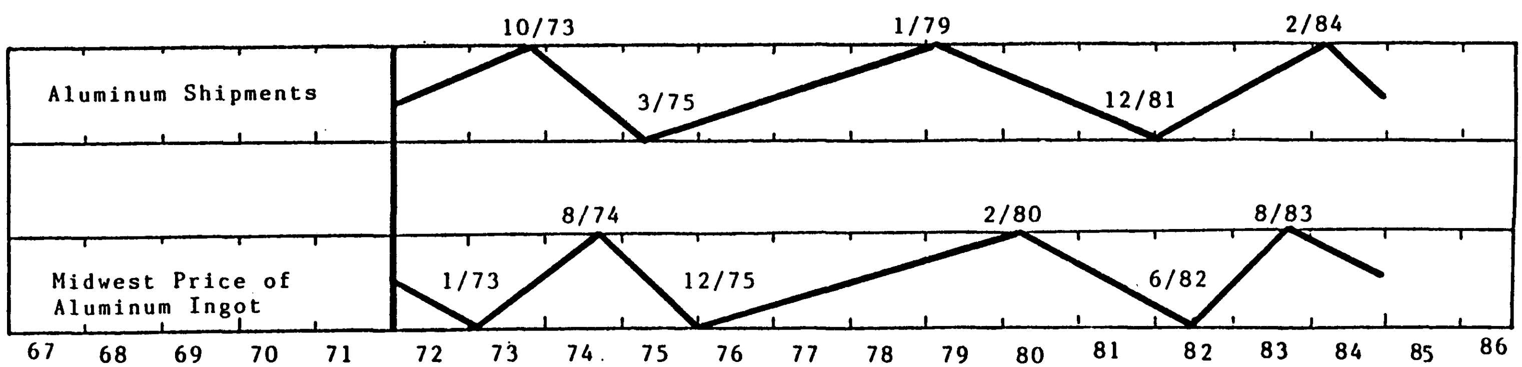
The dealing in aluminum ingot in the Midwest market was recognized in 1972. With the limited data owing to the late publication, there were only six turns during the covered period. It turned out to be mostly lagging to Aluminum Shipments even though there were only five turns available to compare. The latest turn of Midwest Ingot Price in August 1983 was the exception. This turn heralded the peak of Aluminum Shipments six months ahead. There must be more data with more turns to find out the relationship between Midewest Ingot Price and Shipments. With the data given, it can be said that Midwest Ingot Price is a lagging indicator of Aluminum Shipments. Chart A-1 deals with the comparison of Aluminum Shipments to Midwest Ingot Price.

The LME aluminum contract started later in 1978. The size of the data from the LME contract is not enough to reason the relationship with Aluminum Shipments. However, it turned out to be a coincident indicator of Midwest Ingot Price. This means that these two prices are closely connected as free market prices, regardless of geographical

Chart A-1 Aluminum Shipments vis-a-vis Midwest Price of Aluminum Ingot



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS					10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)					10	13	-6				3	0	1	0	0	2	10	6	10	0
TROUGHS					3/75	12/81														
L(-) or Lg(+)					9	6					2	0	0	0	0	2	8	8	2	1
P and T											5	0	1	0	0	4	9	6	7	1



distance.

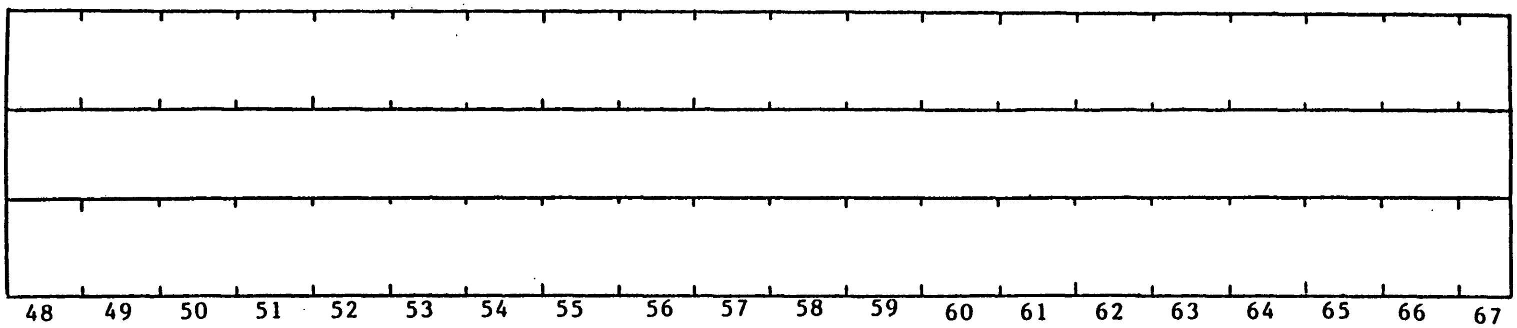
A-1-2 Inventory Change of Producers' Aluminum

Inventory Change of Producers' Aluminum, data available beginning in 1972, has four extra turns as shown in Chart A-2. With only five pairs of turns comparable, it is impossible to determine a relationship. Nonetheless, peaks of Aluminum Shipments correspond to troughs of Inventory Change, and troughs of Aluminum Shipments correspond to peaks of Inventory Change. If the comparison keeps relating peaks to troughs and vice versa, there are five turns of Inventory Change available to compare. This is the maximum number during the covered period because there are only five turns in Aluminum Shipments. It is obvious that Inventory Change will decrease as Aluminum Shipments increase, and Inventory Change will increase as Aluminum Shipments decrease. This will also be the case when Ingot Production is compared with Producers' Inventory Change. Chart A-2 shows the comparison of the inverted data of Inventory Change and Aluminum Shipments.

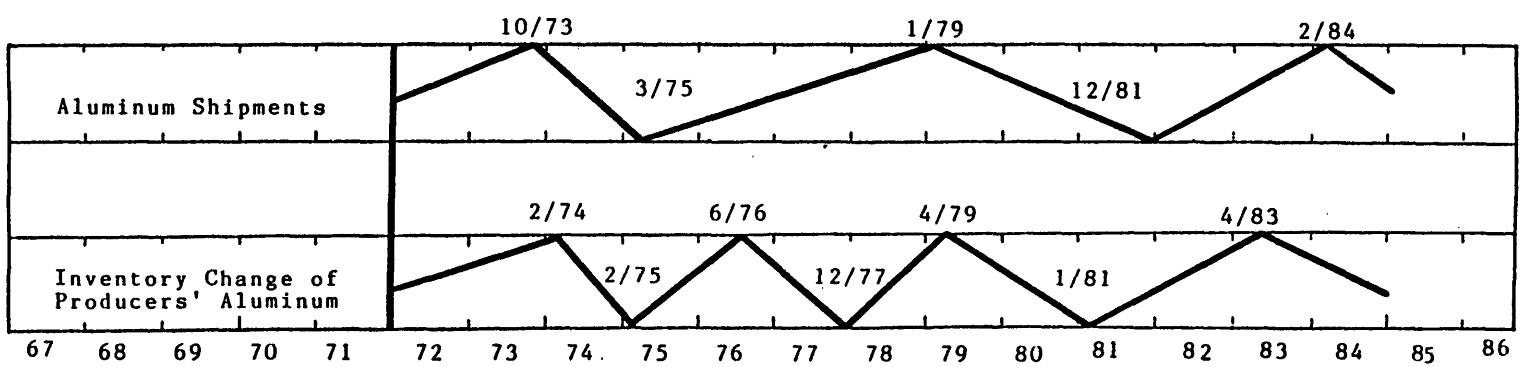
A-1-3 Growth Rate of Earnings in the Primary Aluminum Industry

It is conceivable that Growth Rate of Earnings will decease as the demand for primary aluminum ingot decreases.

Chart A-2 Aluminum Shipments vis-a-vis Inventory Change of Producers' Aluminum



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS					10/73	1/79	2/84						L(-)	±3	0	lg(+)	Md	Mn		
L(-)or Lg(+)					4	3	-10				3	0	1	1	0	2	3	-1	8	1
TROUGHS					3/75	12/81														
L(-) orLg(+)					-1	-11					2	0	2	1	0	0	-6	-6	7	1
P and T											5	0	3	2	0	2	-1	-3	7	2

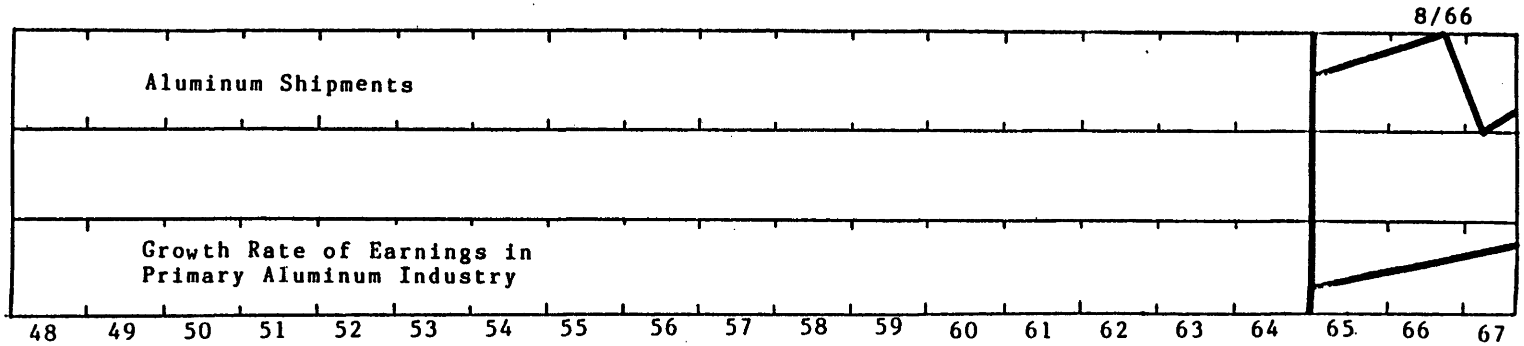


Because Aluminum Shipments is a leading indicator of Aluminum Ingot Production, primary ingot producers will try to slow Growth Rate of Earnings when they see the downturn of Aluminum Shipments. Therefore, Growth Rate of Earnings can lag Aluminum Shipments. In Chart A-3 there are nine observations of turns in Aluminum Shipments during the covered period. Among them, four turns of Aluminum Shipments were skipped by Growth Rate of Earnings. On the other hand, there were two extra turns in Growth Rate of Earnings. Among five turns available to compare in Grwoth Rate of Earnings, two were leading and the other three were lagging. With the standard deviation of leads or lags being huge, it is not possible to define any relationship between these two series.

A-1-4 Employee Numbers in Primary Aluminum Industry

Employee numbers that were considered here are divided into two groups. One is the all Employee Numbers and the other is the Number of Production Workers. These two are coincident indicators to each other. Both are lagging indicators of Aluminum Shipments as shown in Charts A-4 and A-5. There were nine turns in Aluminum Shipments during the time period starting in 1964. Two of them were skipped turns in the 1966-67 time period. The other seven turns in

Chart A-3 Aluminum Shipments vis-a-vis Growth Rate of Earnings



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	lg(+)	Md	Mn		
L(-) or Lg(+)			-	-13	5	32	-				5	2	1	0	0	2	5	8	23	1
TROUGHS			3/67	11/70	3/75	12/81														
L(-) or Lg(+)			-	-7	9	-					4	2	1	0	0	1	1	1	11	1
P and T											9	4	2	0	0	3	5	5	17	2

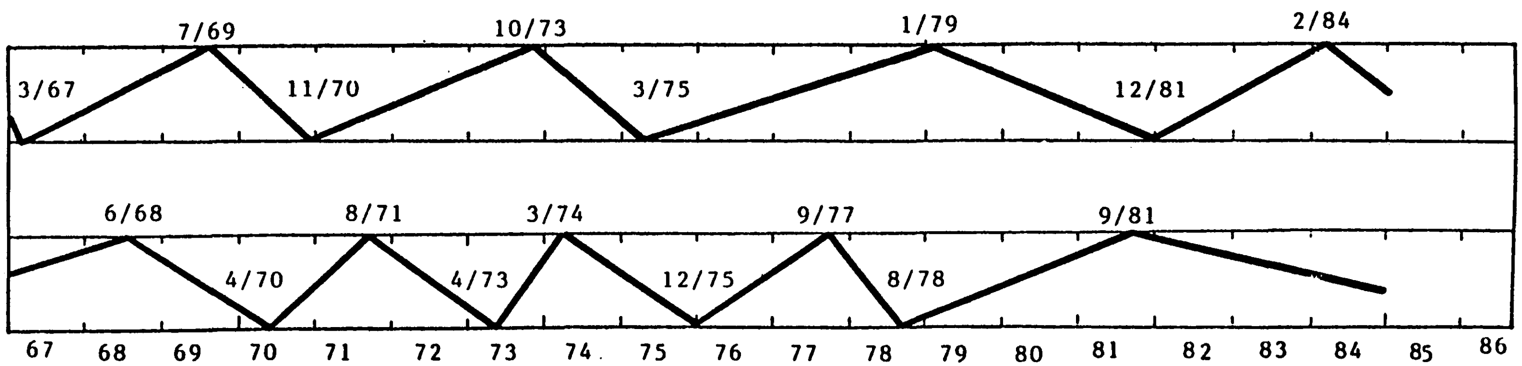
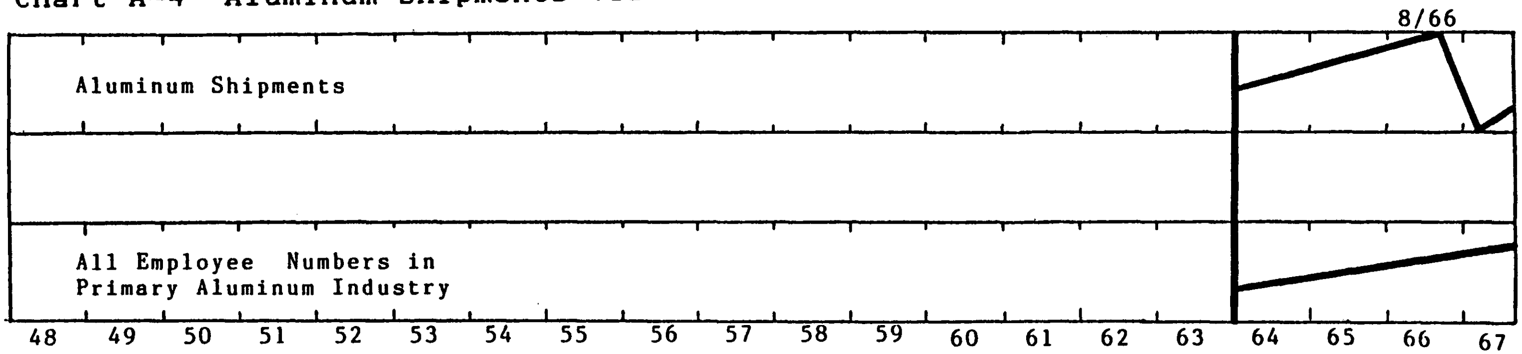


Chart A-4 Aluminum Shipments vis-a-vis All Employee Numbers



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)			-	11	14	14	2				5	1	0	1	0	4	12	10	6	0
TROUGHS			3/67	11/70	3/75	12/81														
L(-) or Lg(+)			-	16	8	15					4	1	0	0	0	3	15	13	4	0
P and T											9	2	0	1	0	7	14	11	5	0

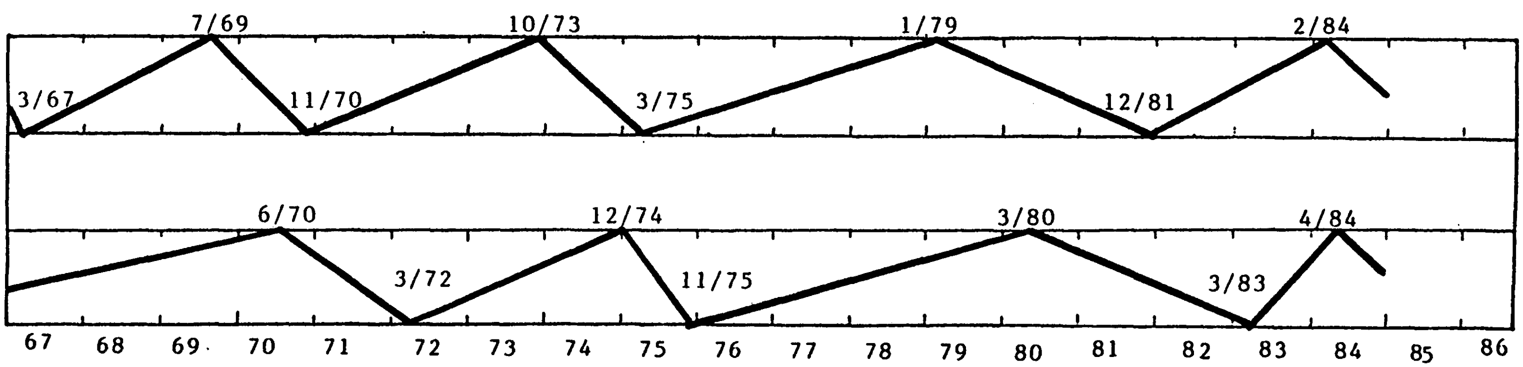
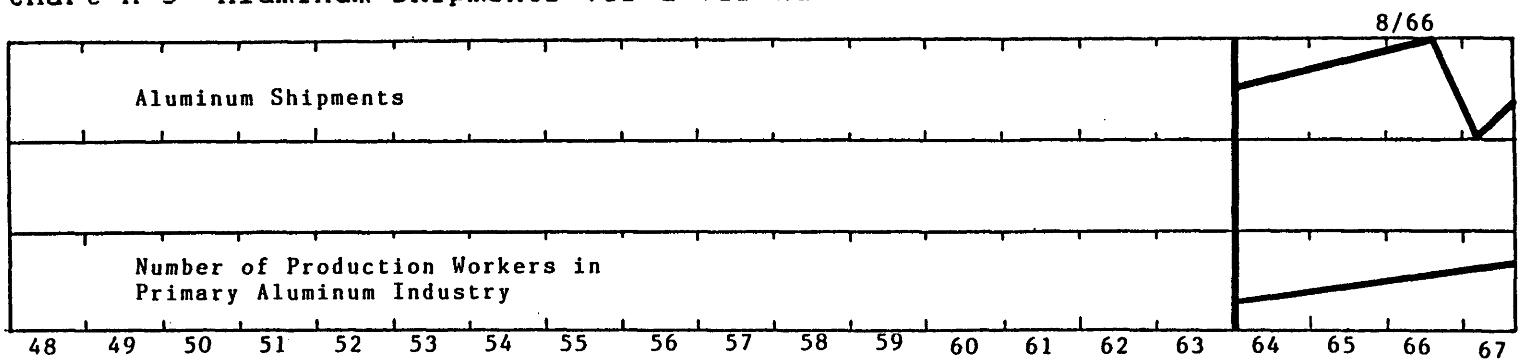
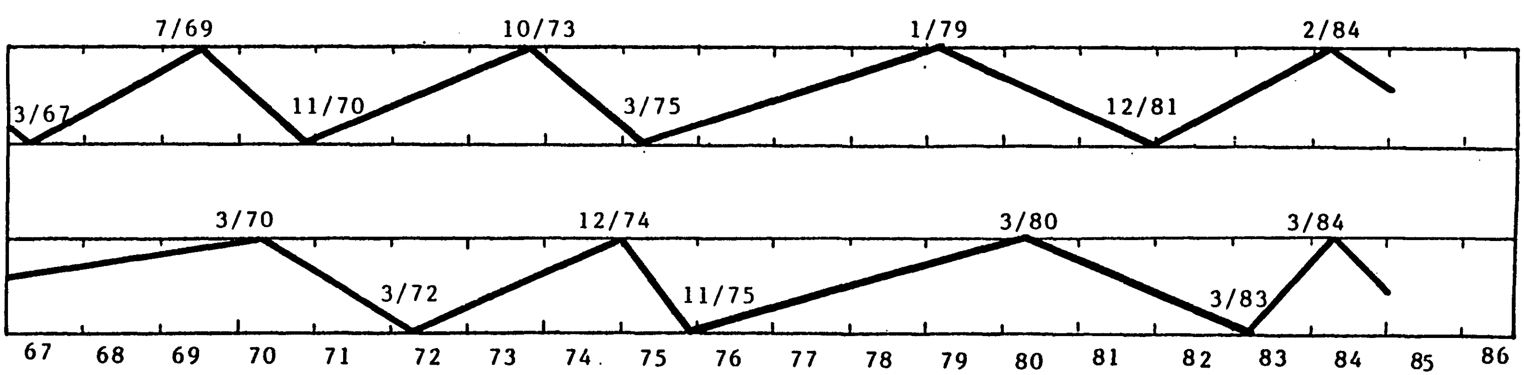


Chart A-5 Aluminum Shipments vis-a-vis Number of Production Workers



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)			-	8	14	14	1				5	1	0	1	0	4	11	9	6	0
TROUGHS			3/67	11/70	3/75	12/81														
L(-) or Lg(+)			-	16	8	15					4	1	0	0	0	3	15	13	4	0
P and T											9	2	0	1	0	7	14	11	5	0

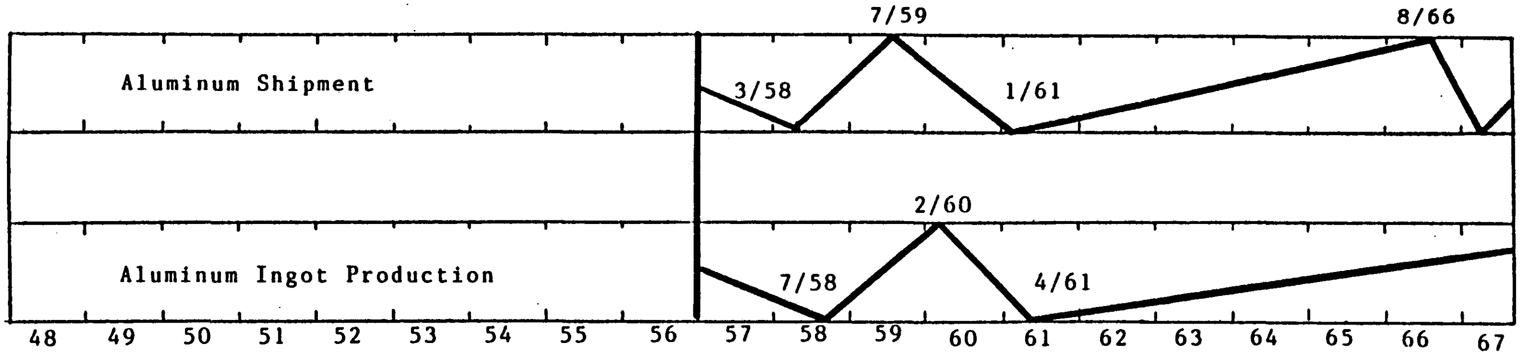


Aluminum Shipments consistently matched the turns in Employee Numbers. The turns in Employee Numbers lagged to those in Aluminum Shipments by a median of fourteen months. It should be interesting to see why the peak and trough of Aluminum Shipments during the 1966-67 period were skipped in Employees Numbers. One might argue that with the short time period of less than one year for these turns, the employment condition is too rigid to be affected by the change in Shipments. However, when Employee Numbers are compared with Ingot Production, they show a more consistent relationship with no skipped and extra turns.

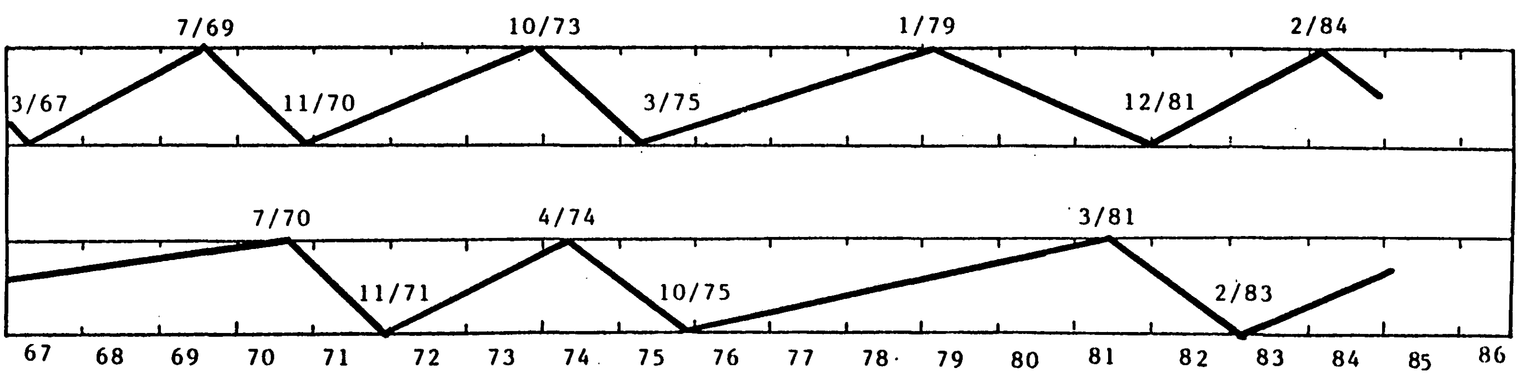
A-1-5 Aluminum Ingot Production

Ingot Production was compared to Aluminum Shipments. Because the production data goes back to 1948, the full data of Aluminum Shipments was considered. Chart A-6 shows that production lags the Shipments. Among twelve possible observations in Aluminum Shipments, three were skipped turns. There was no extra turn in the Ingot Production. There were eight lags in Ingot Production with one consistency. The median value of the lags was seven months. Actually, Aluminum Shipments data reflects Ingot Production. But it also includes scrap, manufactured products, and net imports. Therefore, the reason for

Chart A-6 Aluminum Shipments vis-a-vis Aluminum Ingot Production



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS		7/59	8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	lg(+)	Md	Mn		
L(-)or Lg(+)		7	-	12	6	26	-				5	2	0	0	0	4	10	13	9	0
TROUGHS	3/58	1/61	3/67	11/70	3/75	12/81														
L(-) orLg(+)	4	3	-	12	7	14					6	1	0	1	0	5	7	8	5	0
P and T											11	3	0	1	0	9	7	10	7	0



Aluminum Shipments being a leading indicator of Ingot Production lies in the fact that Shipments include other data described above.

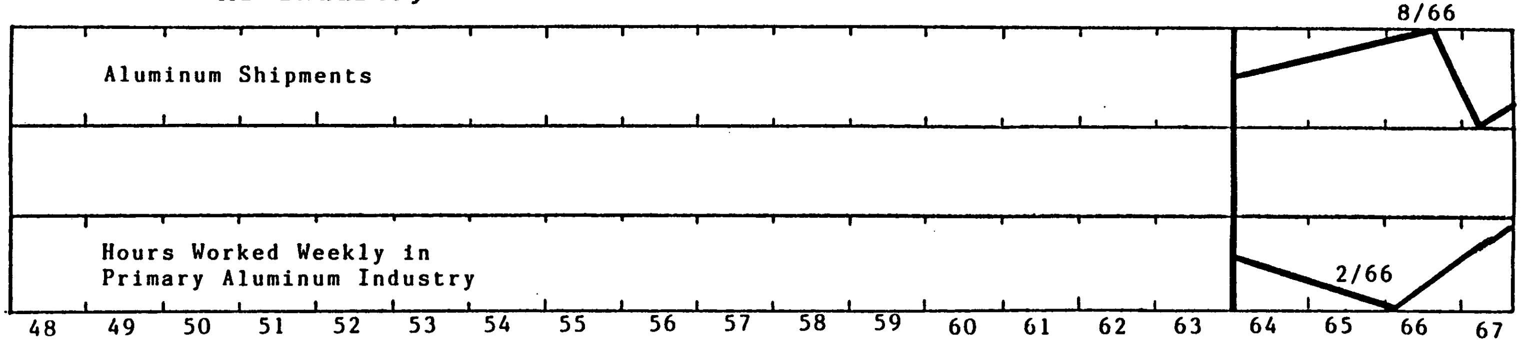
A-1-6 Hours Worked Weekly in the Primary Industry

In Chart A-7, the time series of Hours Worked Weekly in the primary industry is compared to Aluminum Shipments. There were seven extra turns in Hours Worked Weekly. During the time period available for comparison, Aluminum Shipments had nine possible observations. Three of them were skipped turns. It seems that there is no regular relationship between these two series. The time series of Hours Worked Weekly is so erratic that it is not possible to determine any linkage between these two series.

A-1-7 Weekly Overtime Hours of Production Workers in the Primary Aluminum Industry

Weekly Overtime Hours had seven turns including two extra turns, as shown in Chart A-8. It was expected to keep a resonance of cycles with Aluminum Shipments; that is, to go up when Shipments goes up and go down when Shipments goes down. The result of the analysis was favorable to the expectation, with the exception of two extra turns in 1976-77 and one lead in February 1978. The other two turns

Chart A-7 Aluminum Shipments vis-a-vis Hours Worked Weekly in the Primary Al Industry



											No. of Observ.	Skipped Turns	Number of L(-)	Number of ±3	Number of 0	Number of Lg(+)	L(-) or Lg(+) Md	L(-) or Lg(+) Mn	Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			8/66	7/69	10/73	1/79	2/84													
L(-) or Lg(+)			-	-7	6	-7	-				5	2	2	0	0	1	-7	-3	8	3
TROUGHS			3/67	11/70	3/75	12/81														
L(-) or Lg(+)			-	9	3	12					4	1	0	1	0	3	9	8	5	4
P and T											9	3	2	1	0	4	5	3	8	7

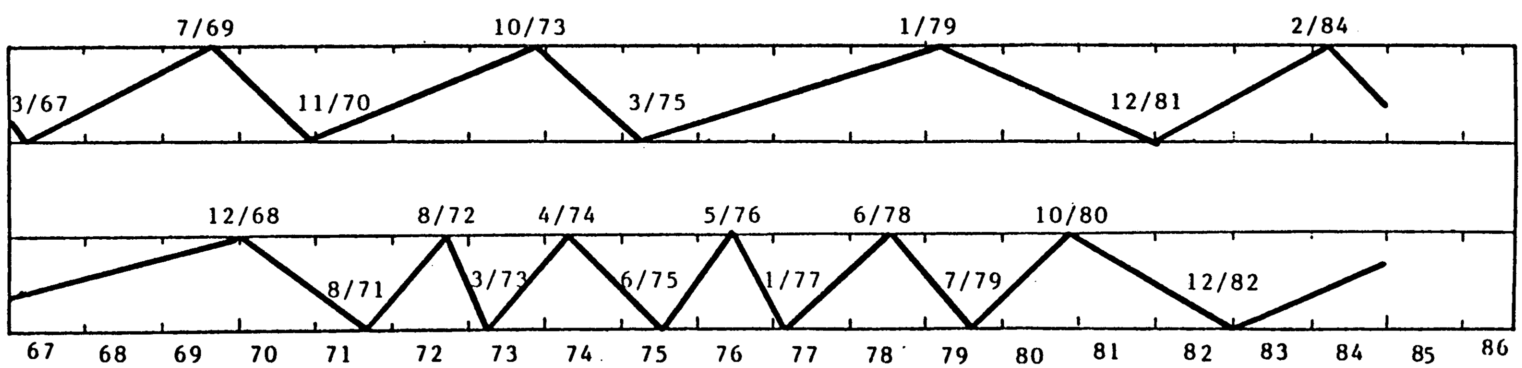
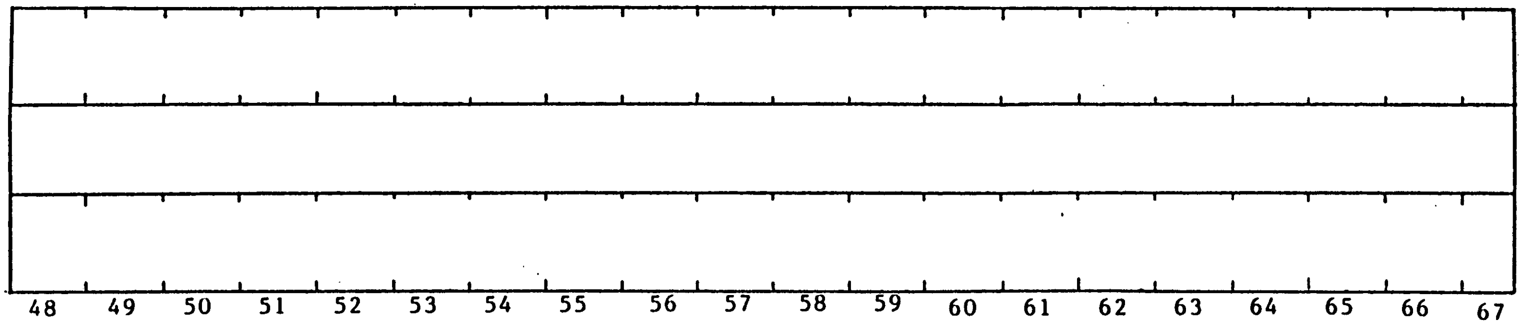
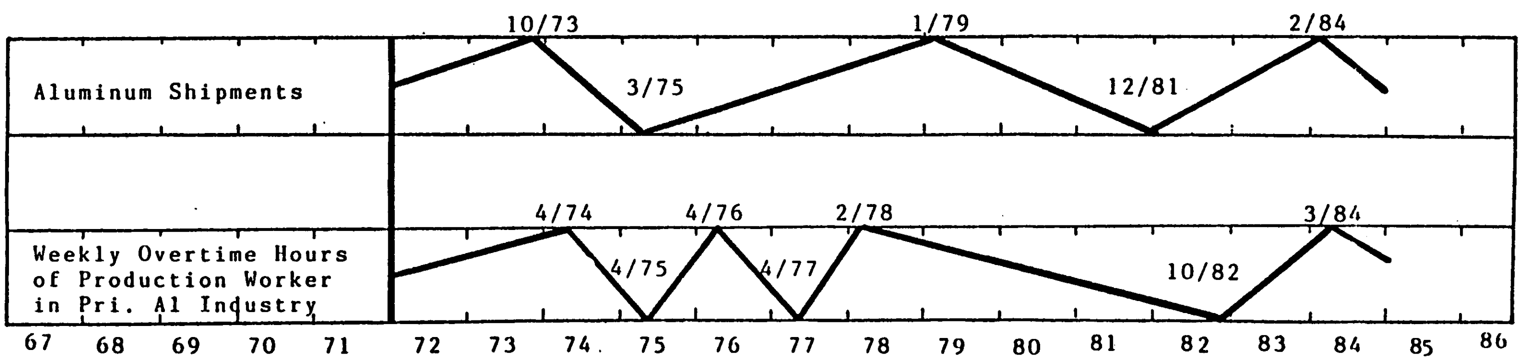


Chart A-8 Aluminum Shipments vis-a-vis Weekly Overtime Hours of Production Workers



PEAKS	10/73	1/79	2/84	No. of Observ.	Skipped Turns	Number of L(-)	Number of ±3	Number of 0	Number of lg(+)	L(-) or Lg(+) Md	L(-) or Lg(+) Mn	Standard Deviation of Lead or Lag	Number of Extra Turns
L(-) or Lg(+)	6	-11	1	3	0	1	1	0	2	1	-1	9	1
TROUGHS	3/75	12/81											
L(-) or Lg(+)	1	10		2	0	0	1	0	2	6	6	6	1
P and T				5	0	1	2	0	4	1	1	8	2



that were compared to those of Aluminum Shipments lagged by a median of one month. Therefore, it could be said that when Aluminum Shipments is about to turn, Hours Worked Weekly will be in the same trend with a one month lag. However, the time interval of lag cannot be forecast correctly, for, with only five pieces of data, it is not justifiable to apply the average value as a credit for the forecasting, especially when these data produce a high standard deviation.

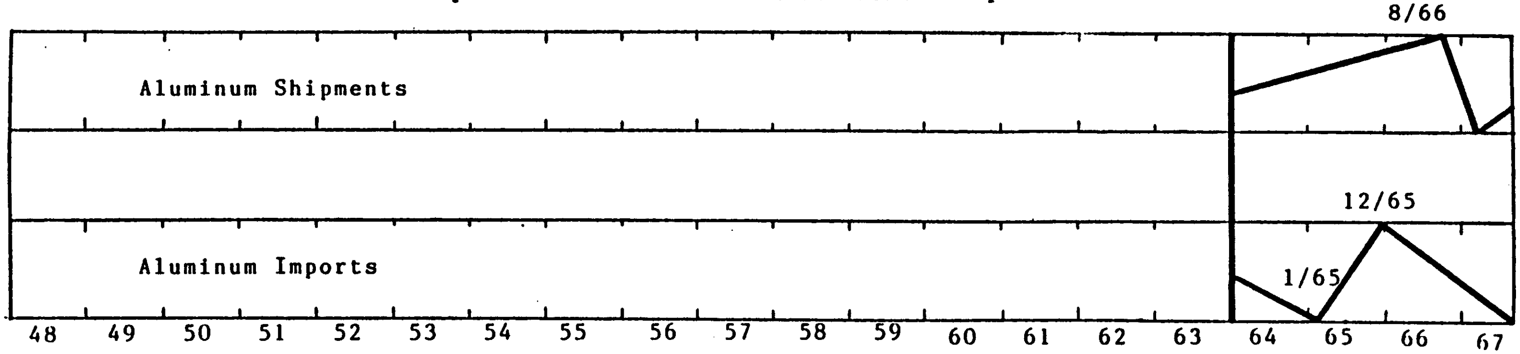
A-1-8 Aluminum Imports, Exports, and Net Imports

Aluminum Imports had six leads, two lags, and three coincidencies. The median lead was six months. Aluminum Exports had two leads, five lags, and four coincidencies. Finally, Net Imports had five leads, three lags, and one coincidency. These three time series had many extra turns. Even though Net Imports is part of Aluminum Shipments, at peaks it led Shipments by a median of twelve months. However, there was no consistent relationship at troughs. The results of the comparisons are shown in Charts A-9, A-10, and A-11.

A-2 Other Indicators of Aluminum Scrap Prices

Some other indicators that did not lead Aluminum Scrap

Chart A-9 Aluminum Shipments vis-a-vis Aluminum Imports



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-)or Lg(+)			-8	-16	-9	-3	-				5	1	4	1	0	0	-8	-9	5	1
TROUGHS			3/67	11/70	3/75	12/81														
L(-) orLg(+)			4	2	2	-19					4	0	2	2	0	2	0	-4	10	2
P and T											9	1	6	3	0	2	-6	-6	8	3

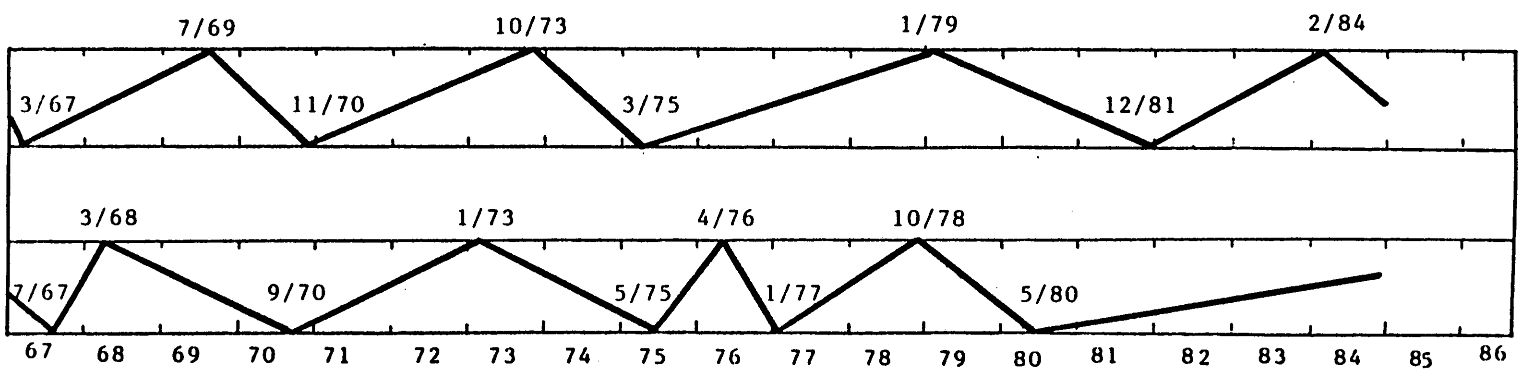
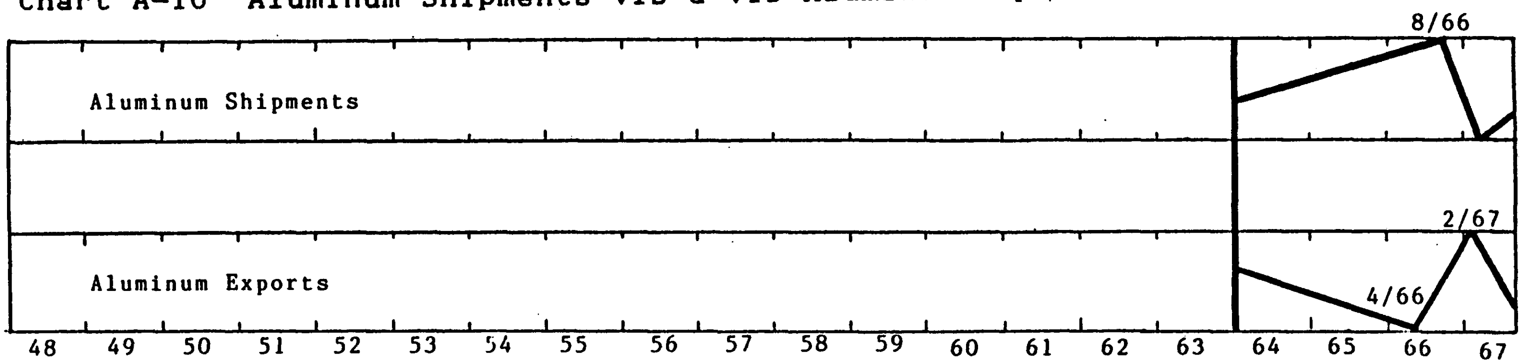


Chart A-10 Aluminum Shipments vis-a-vis Aluminum Exports



						No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS	8/66	7/69	10/73	1/79	2/84			L(-)	±3	0	lg(+)	Md	Mn		
L(-)or Lg(+)	6	6	1	0	-20	5	0	1	1	1	3	1	-1	11	2
TROUGHS	3/67	11/70	3/75	12/81											
L(-) orLg(+)	9	11	0	-3		4	0	1	1	1	2	4	4	7	3
P and T						9	0	2	2	2	5	1	1	9	5

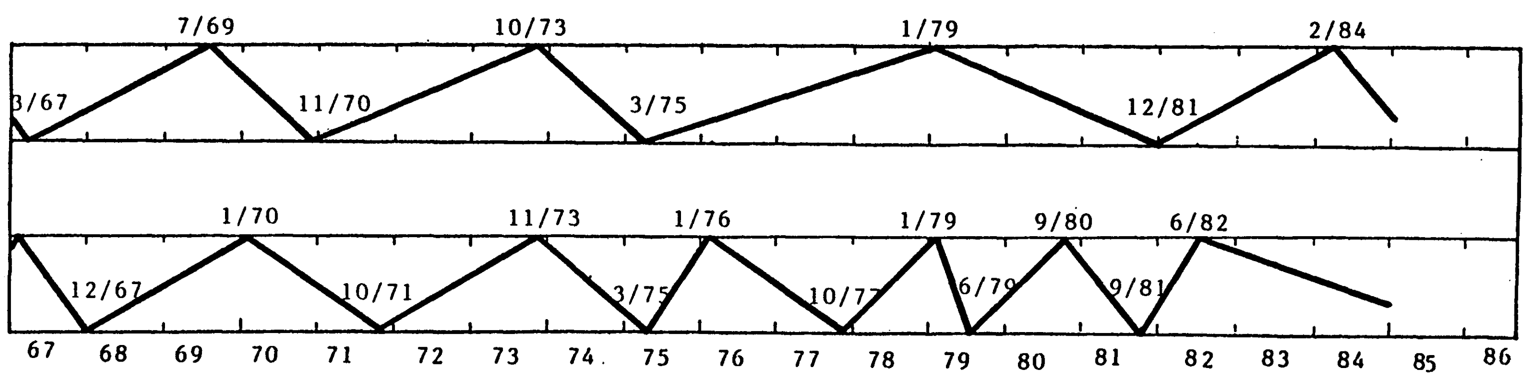
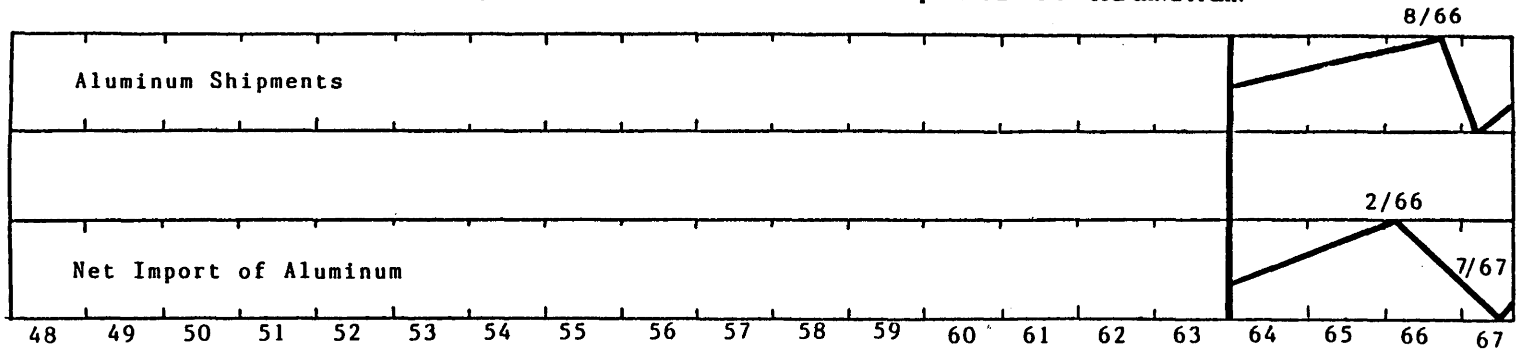
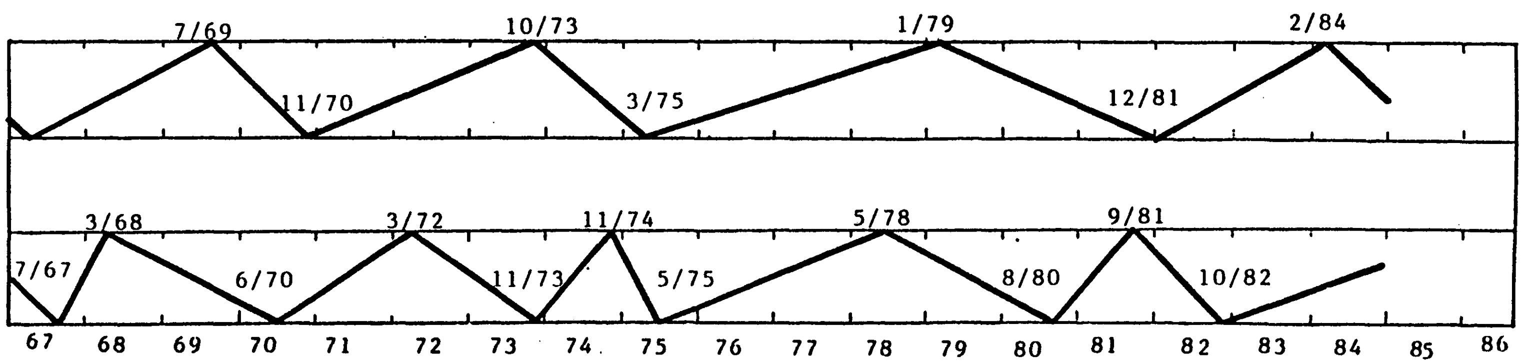


Chart A-11 Aluminum Shipments vis-a-vis Net Imports of Aluminum



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS			8/66	7/69	10/73	1/79	2/84						L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)			-6	-16	-19	-8	-				5	1	4	0	0	0	-12	-12	6	2
TROUGHS			3/67	11/70	3/75	12/81														
L(-) or Lg(+)			4	-5	2	10					4	0	1	1	0	3	3	3	6	2
P and T											9	1	5	1	0	3	-6	-5	10	4



Prices are discussed briefly.

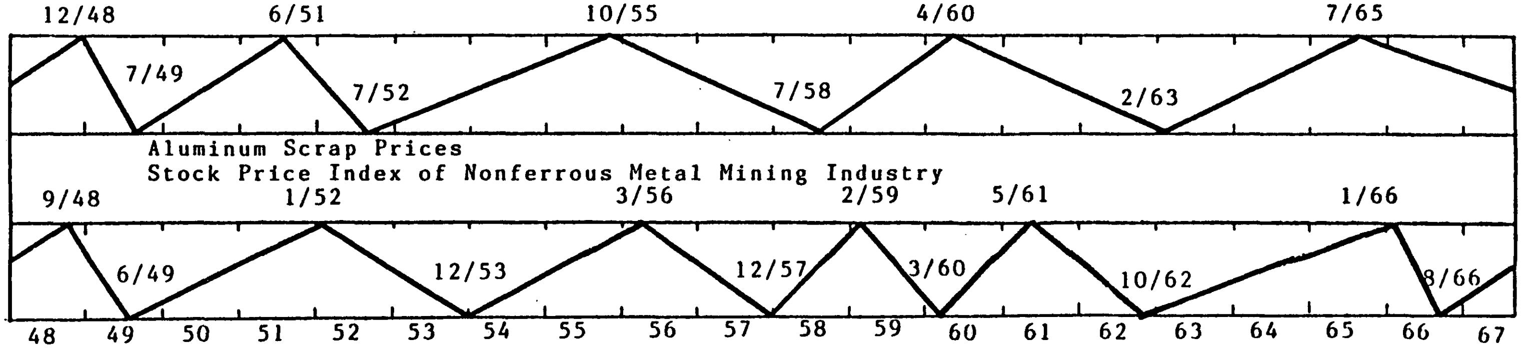
A-2-1 Stock Price Index of Nonferrous Metal Mining Industry (METALS)

Apparently, there is no relationship between Aluminum Scrap Prices and Stock Price Index of Nonferrous Metal Mining Industry. The latter was compared with the former only as a reference. This fact is confirmed in the comparison shown in Chart A-12. Out of seventeen turns in the Stock Price Index compared to those of Aluminum Scrap Prices ten led, seven lagged, and three showed coincidencies. The median lag at peaks was five months while the median lead at troughs was five months. With this result, it is difficult to find any consistent relationship between these two series. Therefore, the Stock Price Index was dropped as a candidate for any kind of indicator.

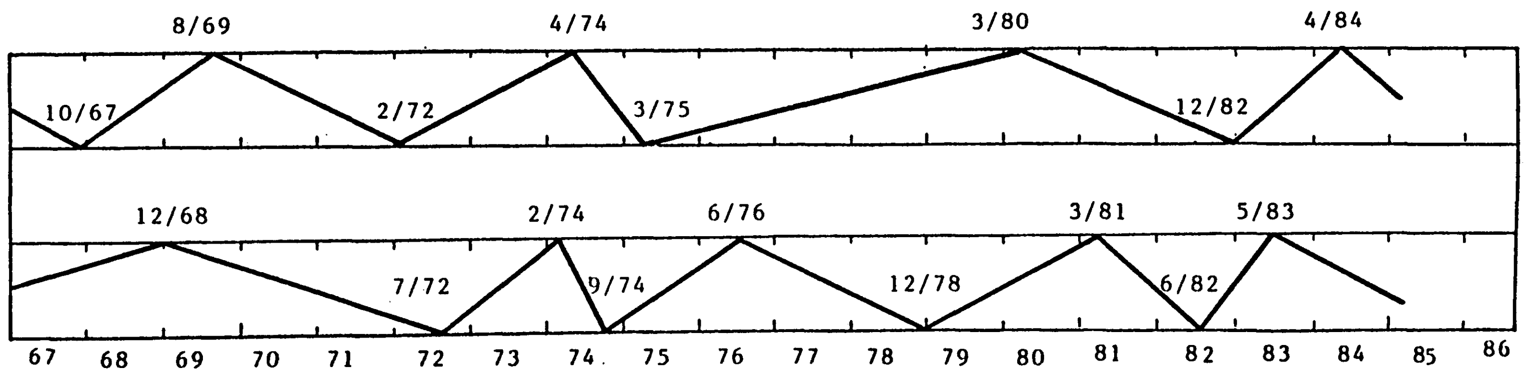
A-2-2 Midwest Price of Aluminum Ingot

The result of this analysis is divided into two directions. There were six turning points since 1972 in the Midwest Price of Aluminum Ingot. The first three turns lagged and next three led. Only one of these turns, February 1980, was roughly coincident with a peak of

Chart A-12 Aluminum Scrap Prices vis-a-vis Stock Price Index of Nonferrous Metal Mining



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS	12/48	6/51	10/55	4/60	7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-) or Lg(+)	-3	7	5	13	6	-8	-2	12	-11		9	0	4	2	0	5	5	2	9	2
TROUGHS	7/49	7/52	7/58	2/63	10/67	2/72	3/75	12/82												
L(-) or Lg(+)	-1	17	-7	-4	-14	5	-6	-6			8	0	6	1	0	2	-5	-2	9	2
P and T											17	0	10	3	0	7	-2	0	9	4

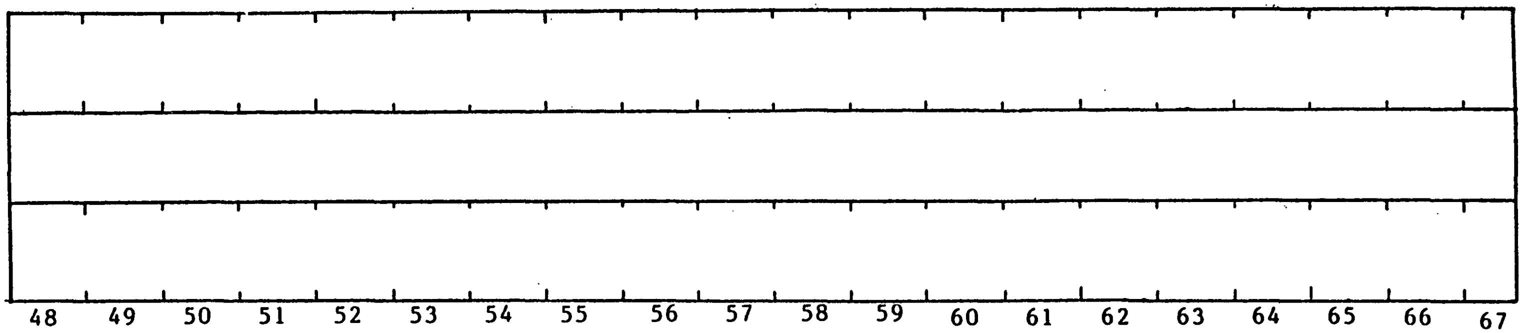


Aluminum Scrap Prices. With this erratic outcome of leads or lags it is not possible to assume any relationship of Midwest Ingot Prices to Scrap Prices. Chart A-13 shows the aspect of the comparison of two series.

A-2-3 Inventory Change of Producers' Aluminum

In Chart A-14 Inventory Change was compared with Aluminum Scrap Prices. The Inventory change had to be inverted because its move takes opposite direction. It seems that turning points of Scrap Prices don not match well with those of the inverted Inventory Change of Producers' Aluminum. If there were any kind of resonance in variations of the Scrap Prices with those of the Inventory Change, it might be concluded that the Inventory Change has some effect on the movement of the Scrap Prices. Inventory Change of Producers' Aluminum produced five leads out of six turns. The trough of Aluminum Scrap Prices in February 1972 was not comparable owing to the lack of a corresponding trough of the inverted Inventory Chnage of Producers' Aluminum during the period covered, starting from January 1972. The median of leads was eleven months. The result of the analysis suggests that the inverted Inventory Change could be a leading indicator without any confident exhibition of its connection with the Scrap

Chart A-13 Aluminum Scrap Prices vis-a-vis Midwest Price of Aluminum Ingot



											No. of Observ.	Skipped Turns	Number of L(-)	Number of ±3	Number of 0	Number of Lg(+)	L(-) or Lg(+) Md	L(-) or Lg(+) Mn	Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS							4/74	3/80	4/84											
L(-)or Lg(+)							4	-1	-8		3	0	2	1	0	1	-1	-2	6	0
TROUGHS						2/72	3/75	12/82												
L(-) or Lg(+)						11	9	-6			3	0	1	0	0	2	9	5	9	0
P and T											6	0	3	1	0	3	2	2	8	0

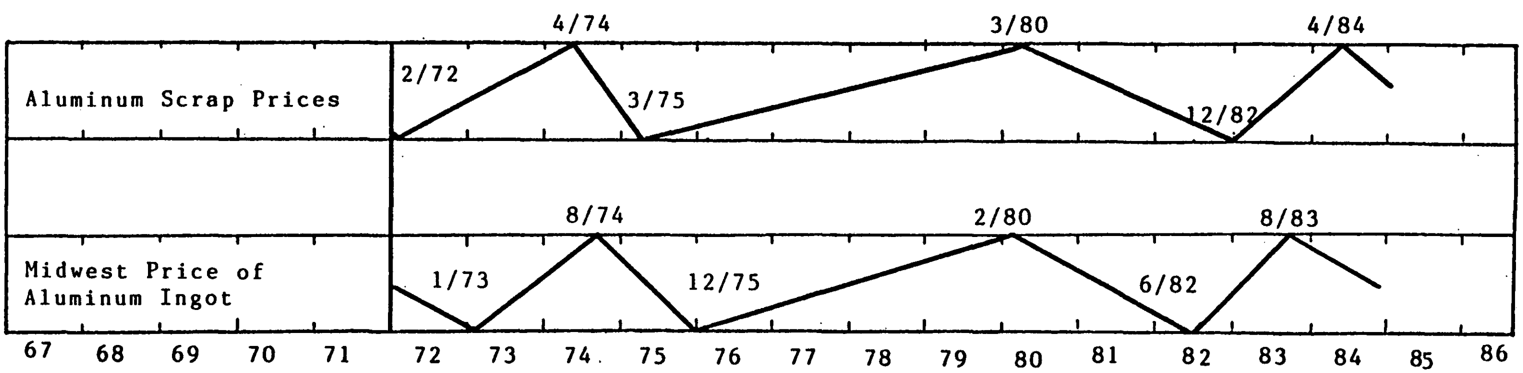
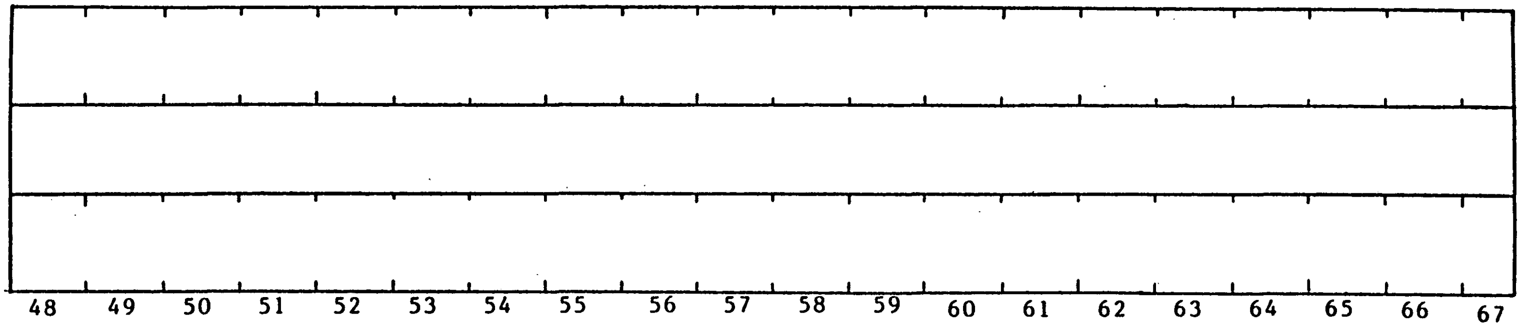
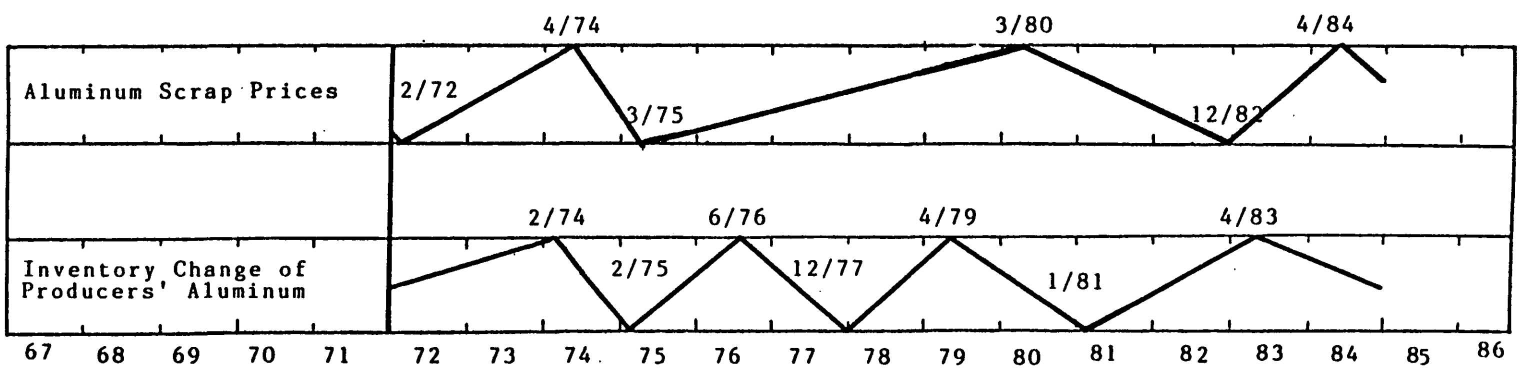


Chart A-14 Aluminum Scrap Prices vis-a-vis Inventory Change of Producers' Aluminum



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS							4/74	3/80	4/84				L(-)	±3	0	lg(+)	Md	Mn		
L(-)or Lg(+)							-2	-11	-12		3	0	3	1	0	0	-11	-8	6	1
TROUGHS						2/72	3/75	12/82												
L(-) orLg(+)						—	-1	-23			3	1	2	1	0.	0	-12	-12	16	1
P and T											6	1	5	2	0	0	-11	-10	9	2

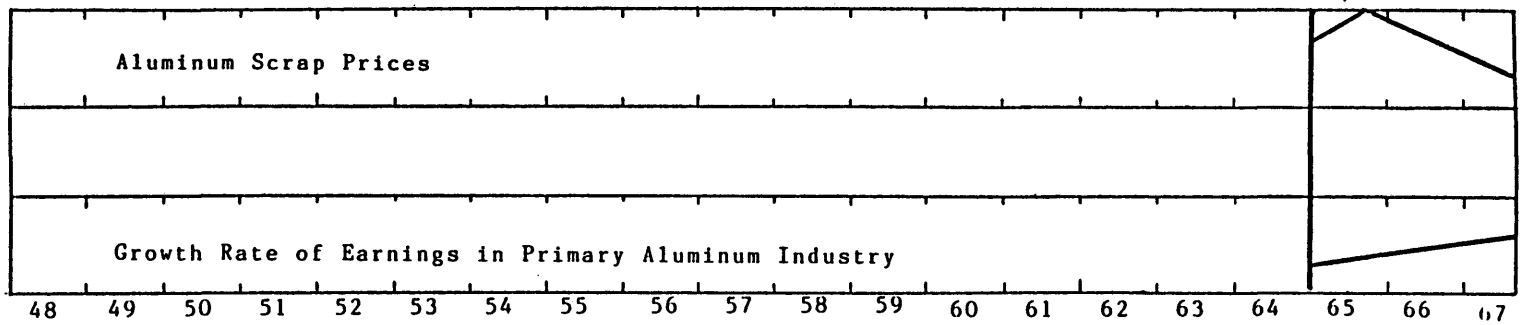


Prices. Therefore, it was not considered as a component for the Leading Index of Scrap Prices.

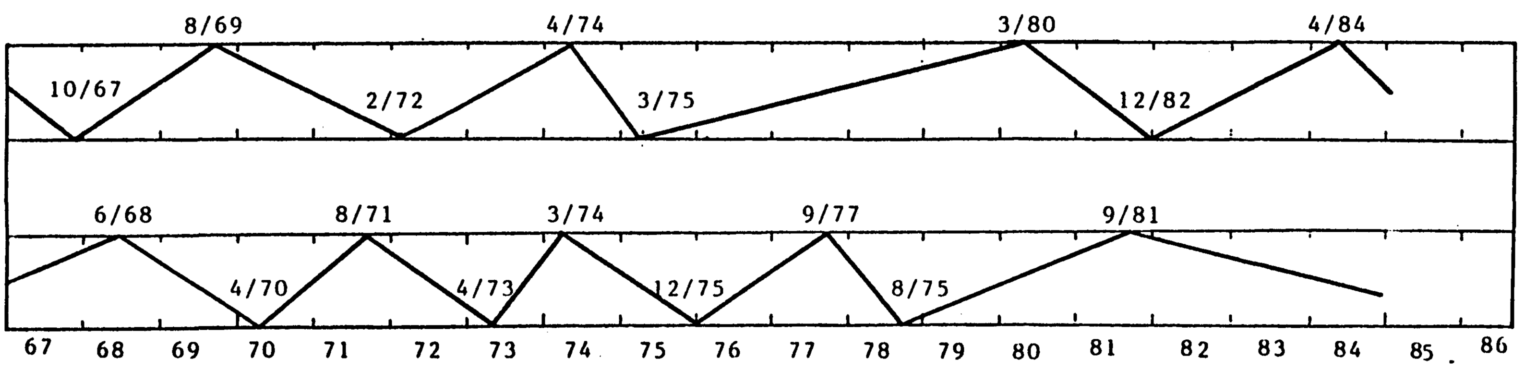
A-2-4 Growth Rate of Earnings in Primary Aluminum Industry

The comparison shown in Chart A-15 reveals that there is no consistent relationship between Growth Rate of Earnings of Primary Aluminum Industry and Aluminum Scrap Prices. There were four extra turns in the Growth Rate of Earnings which had two leads and three lags. The standard deviation for lead or lag was exceptionally high.

Chart A-15 Aluminum Scrap Prices vis-a-vis Growth Rate of Earnings in Primary Al Industry



											No. of Observ.	Skipped Turns	Number of				L(-) or Lg(+)		Standard Deviation of Lead or Lag	Number of Extra Turns
PEAKS					7/65	8/69	4/74	3/80	4/84				L(-)	±3	0	Lg(+)	Md	Mn		
L(-)or Lg(+)					—	-14	-1	18			5	2	2	1	0	1	-1	1	16	2
TROUGHS					10/67	2/72	3/75	12/82												
L(-) orLg(+)					—	14	9	—			4	2	0	0	0	2	12	12	4	2
P and T											9	4	2	1	0	3	9	5	13	4



APPENDIX B

FIGURES OF TIME SERIES

Figure B-1 Stock Price Index of Aluminum Smelters

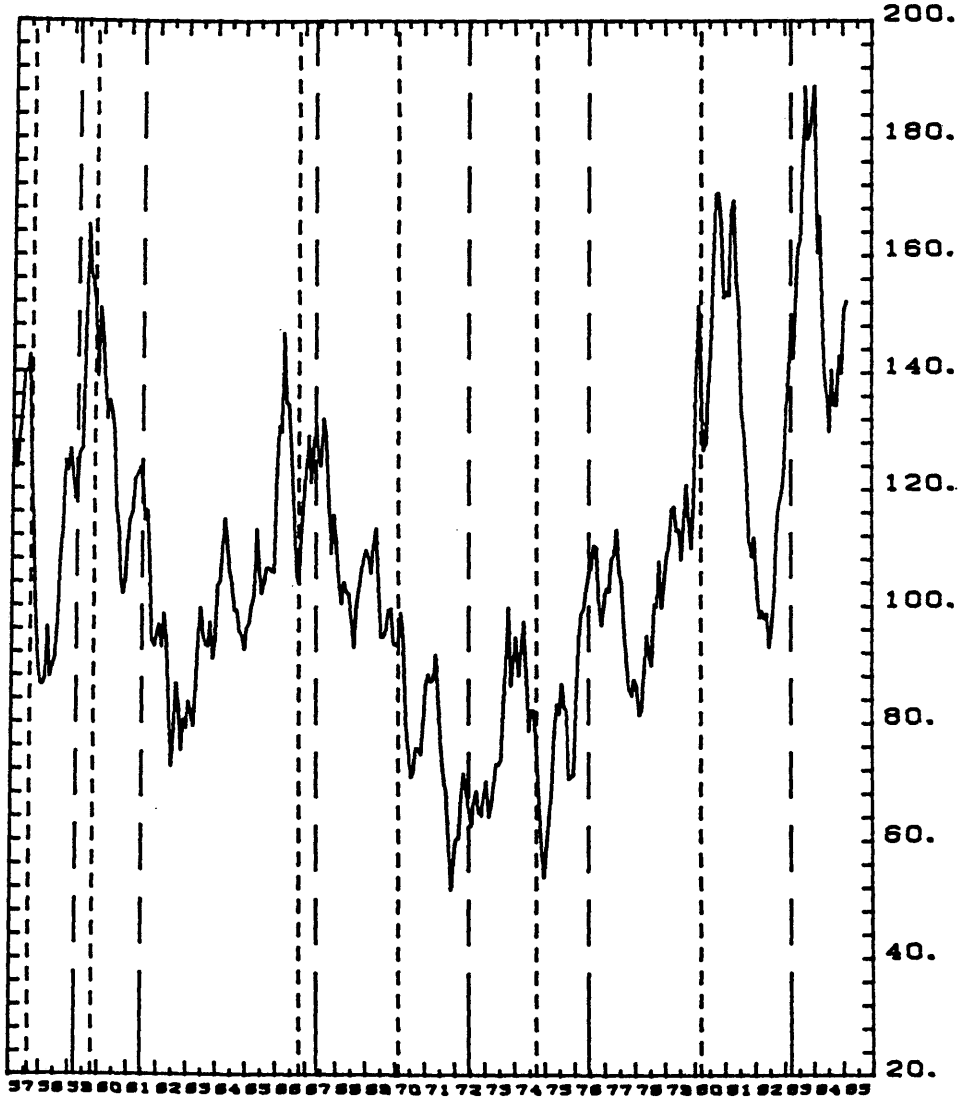


Figure B-2 New Orders of Aluminum

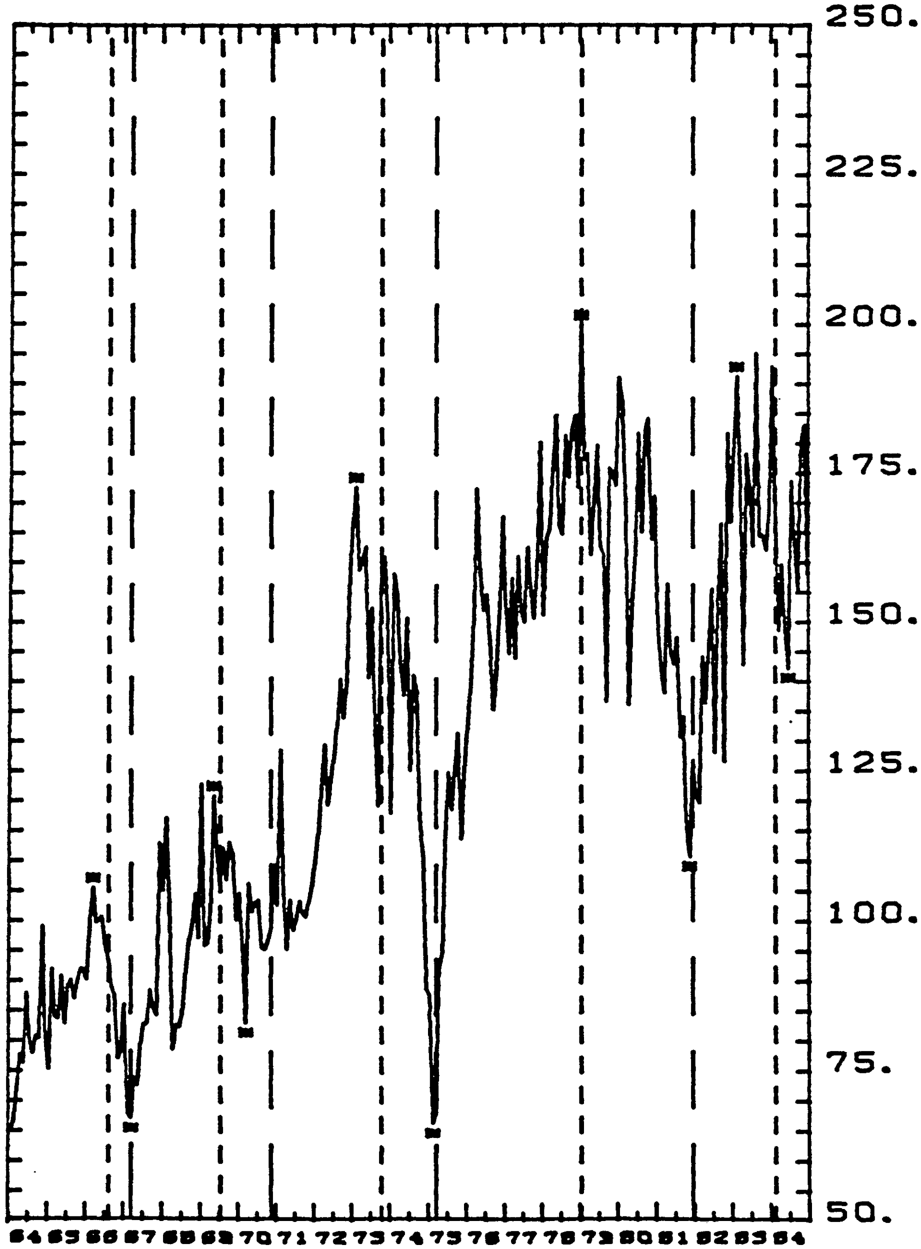


Figure B-3 Monthly Production of Primary Aluminum

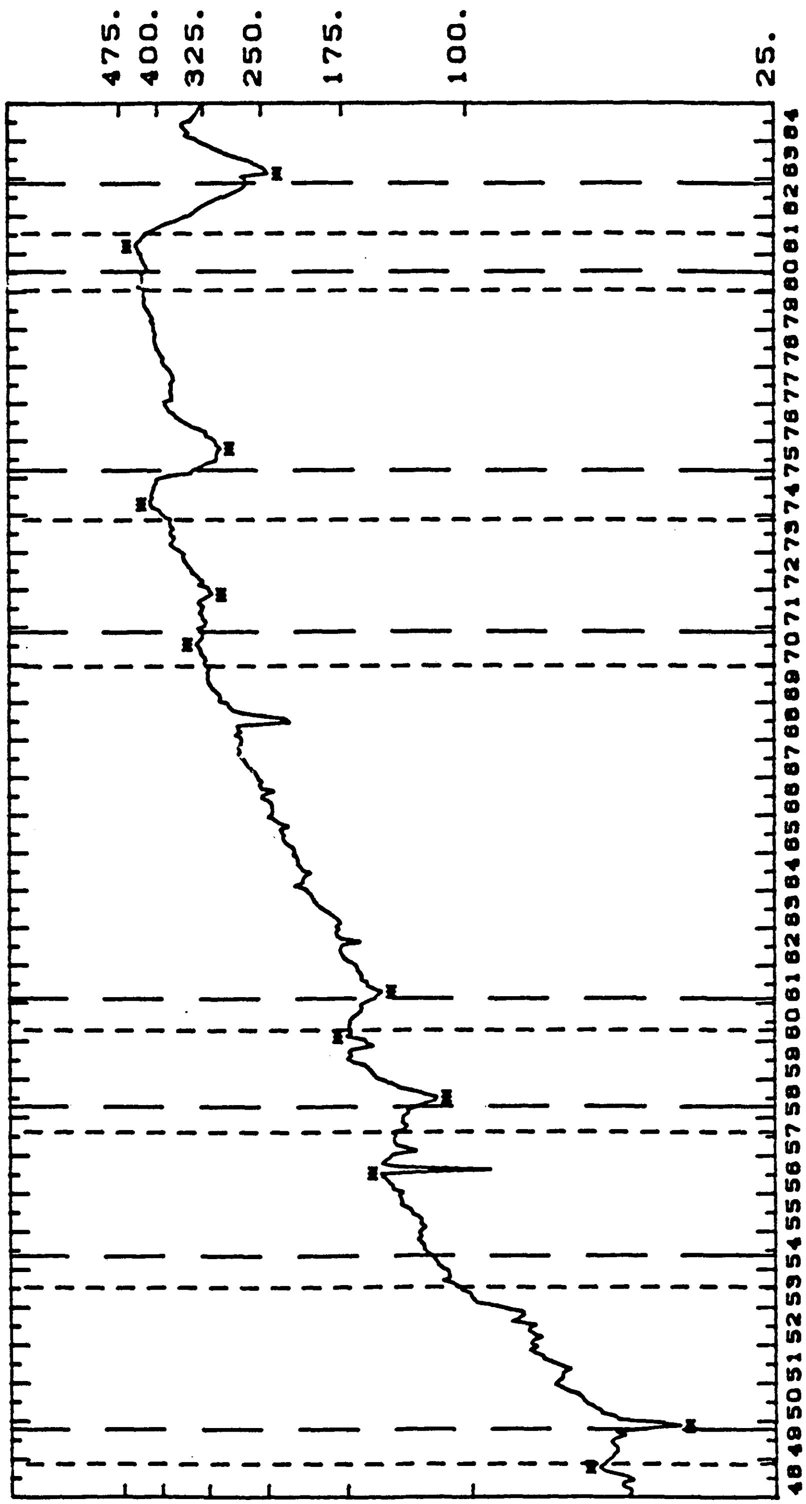


Figure B-4 Local Building Permits

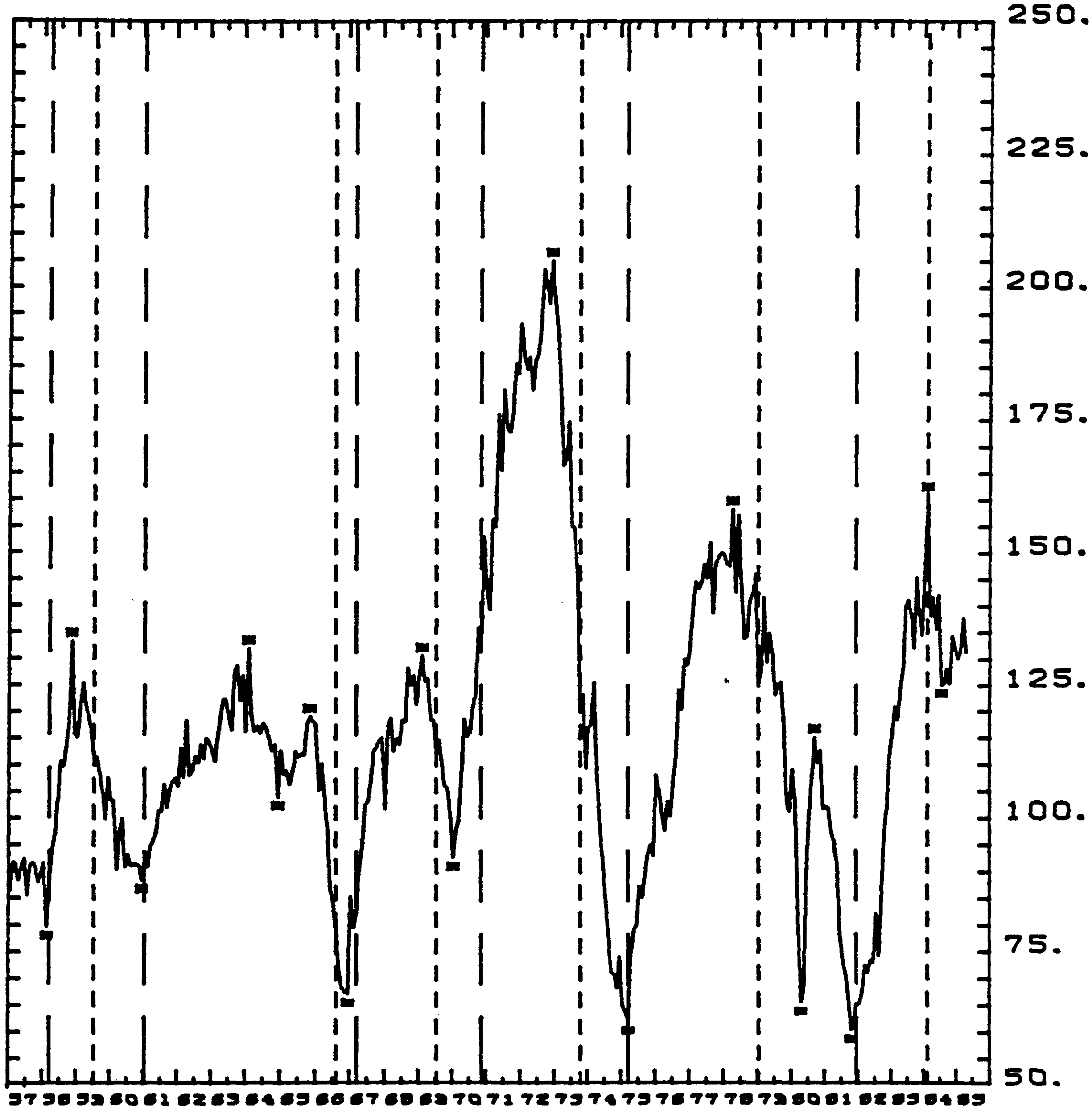


Figure B-5 Mobile Home Shipments

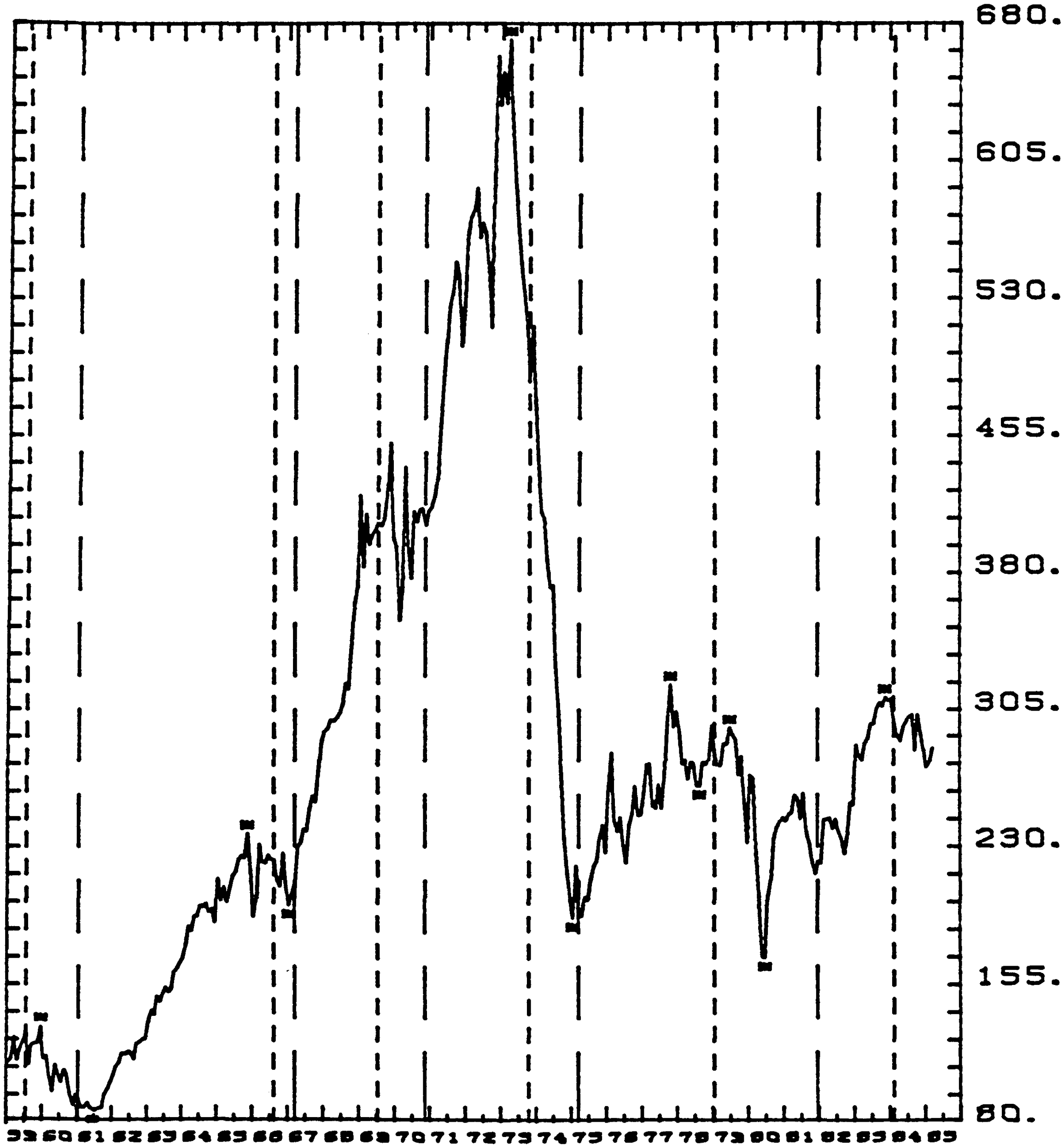


Figure B-6 Monthly Sales of Cars

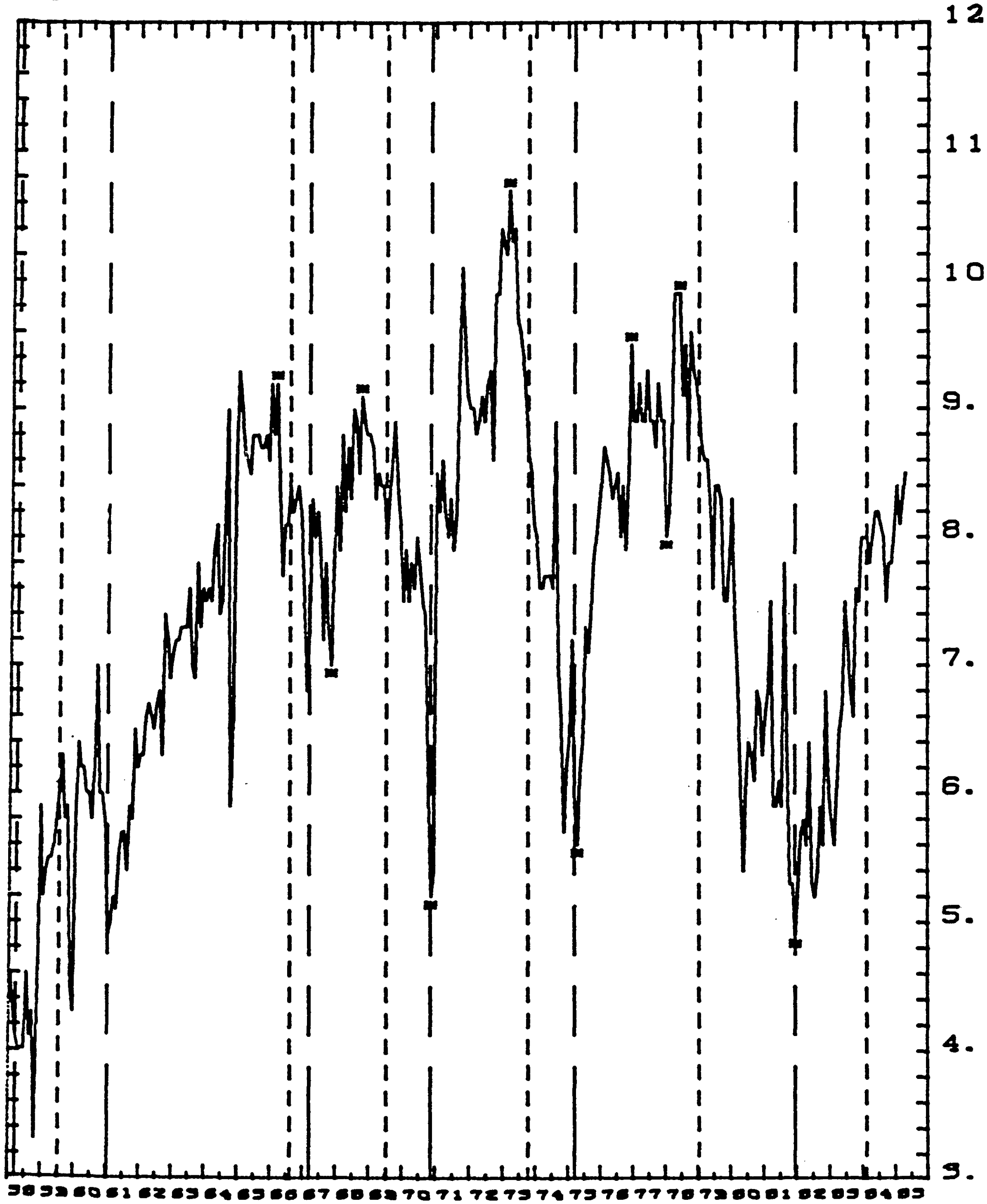


Figure B-7 Hours Worked Weekly in Al Industry

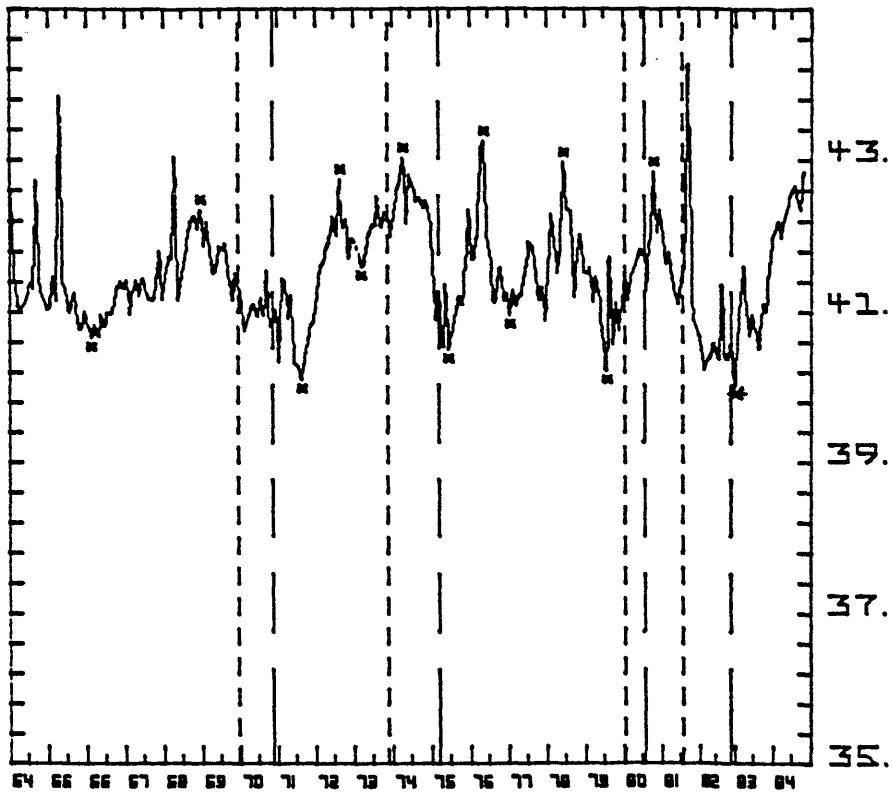


Figure B-8 Leading Index of Business Cycle

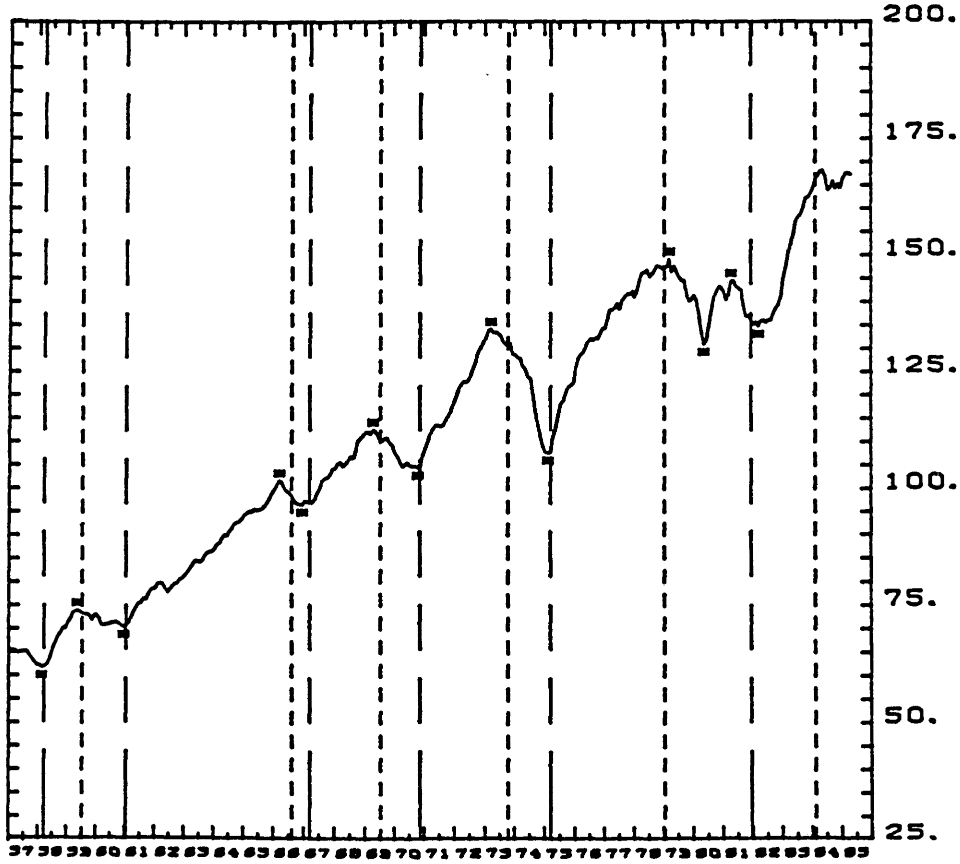
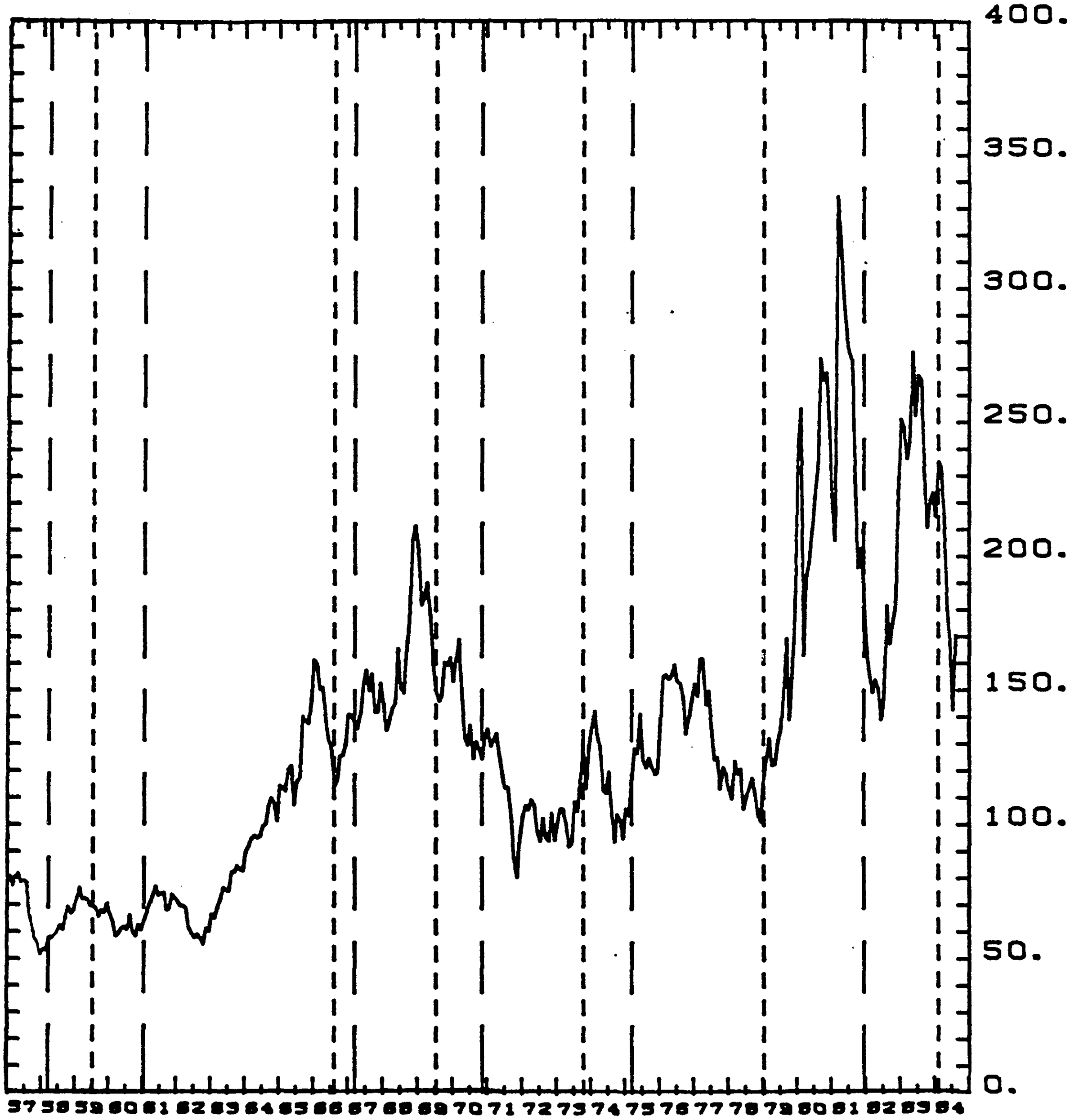


Figure B-9 Stock Price Index of Nonferrous Metal Mining Industry



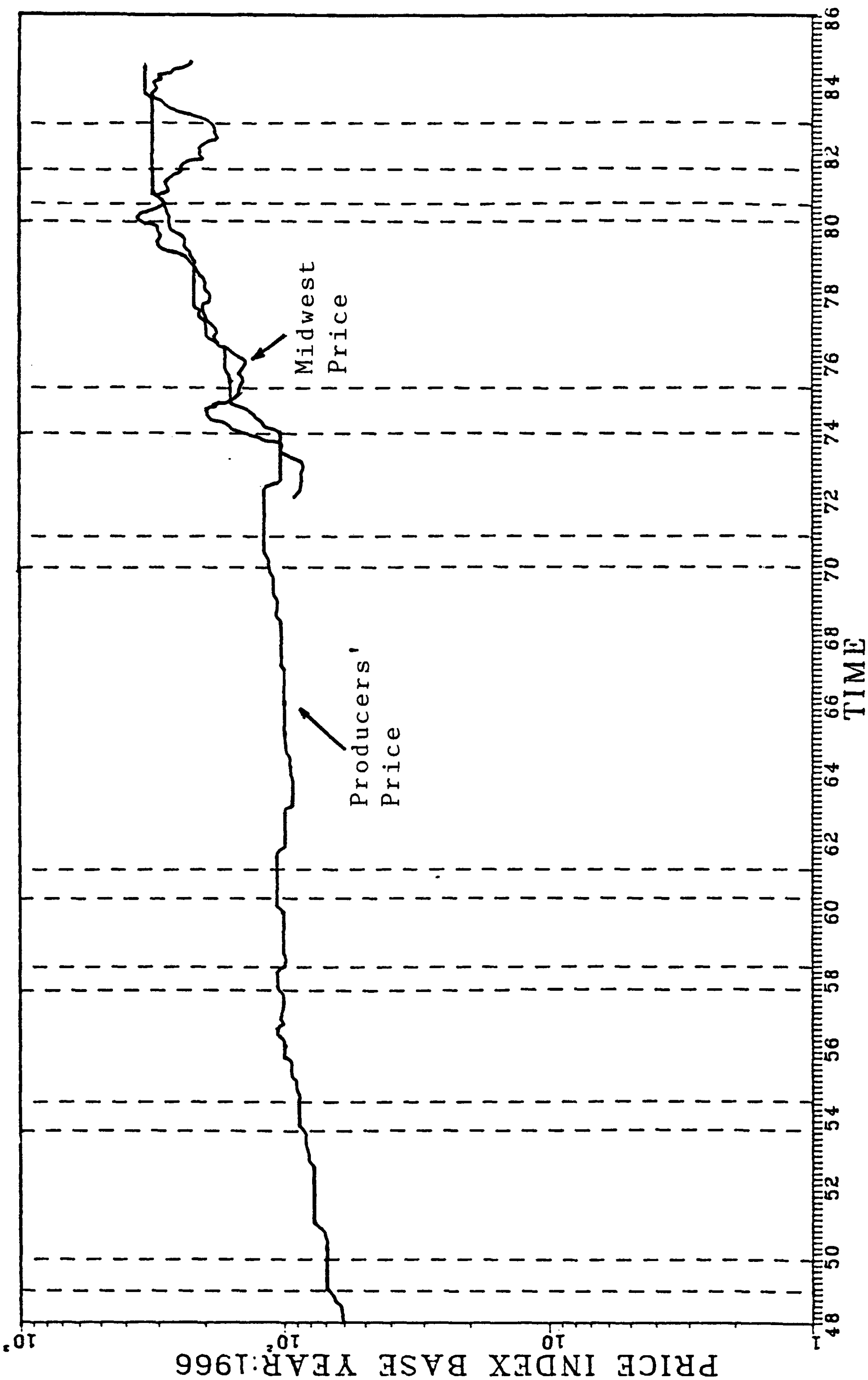


Figure B-10 Primary Aluminum Price Series

Figure B-11 Producers' Inventories

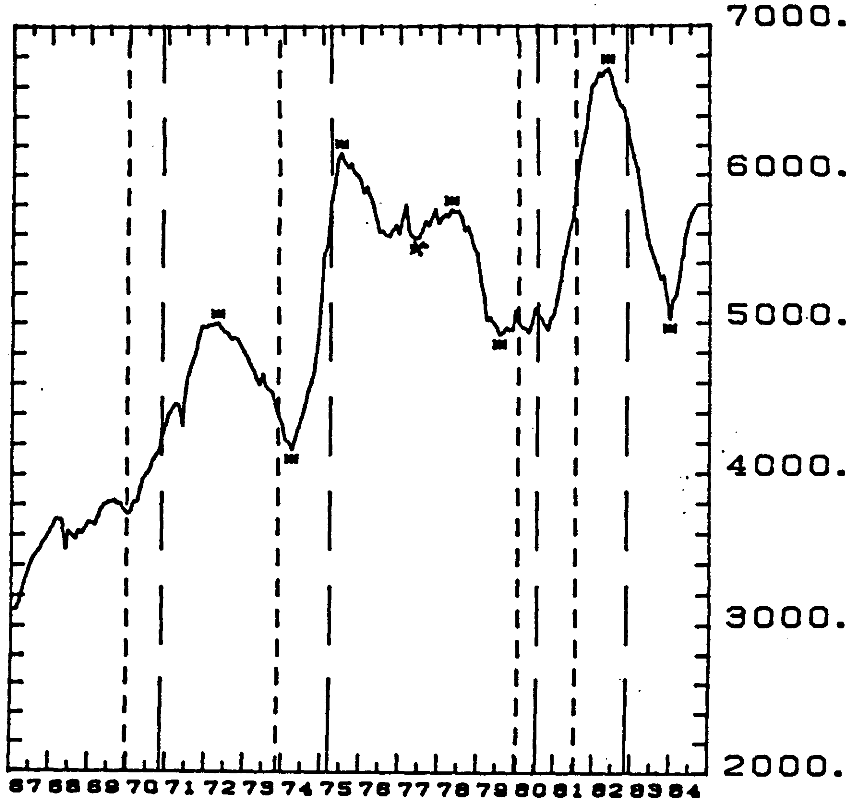


Figure B-12 All Employee Numbers in Primary Al Industry

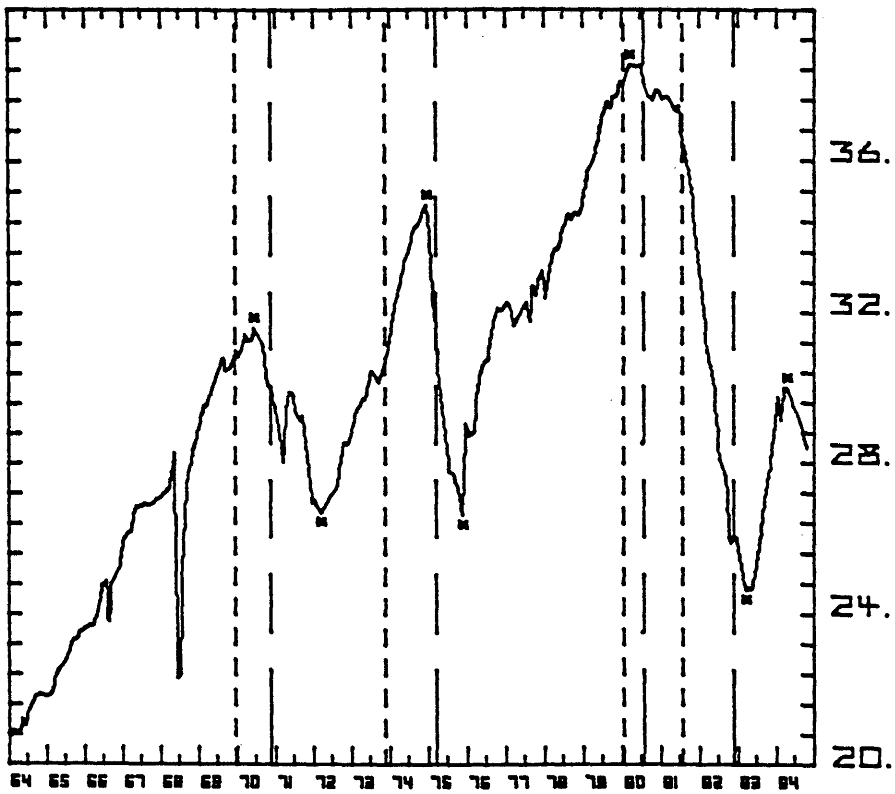


Figure B-13 Number of Production Workers in Primary Al Industry

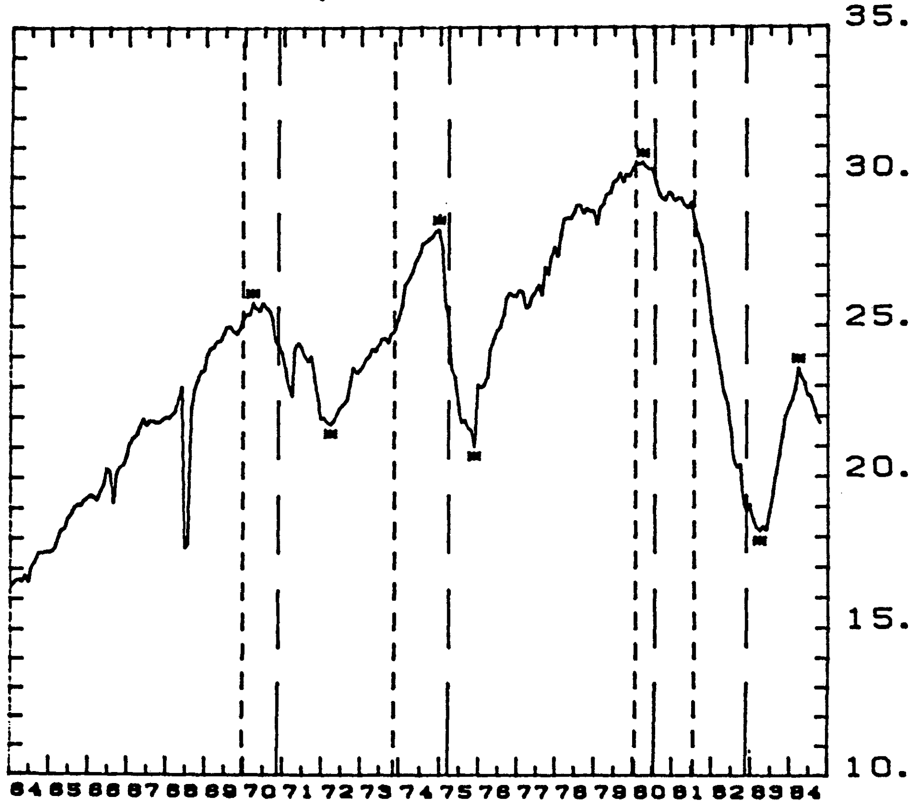


Figure B-14 Weekly Overtime Hours of Production Worker in Primary Al Industry

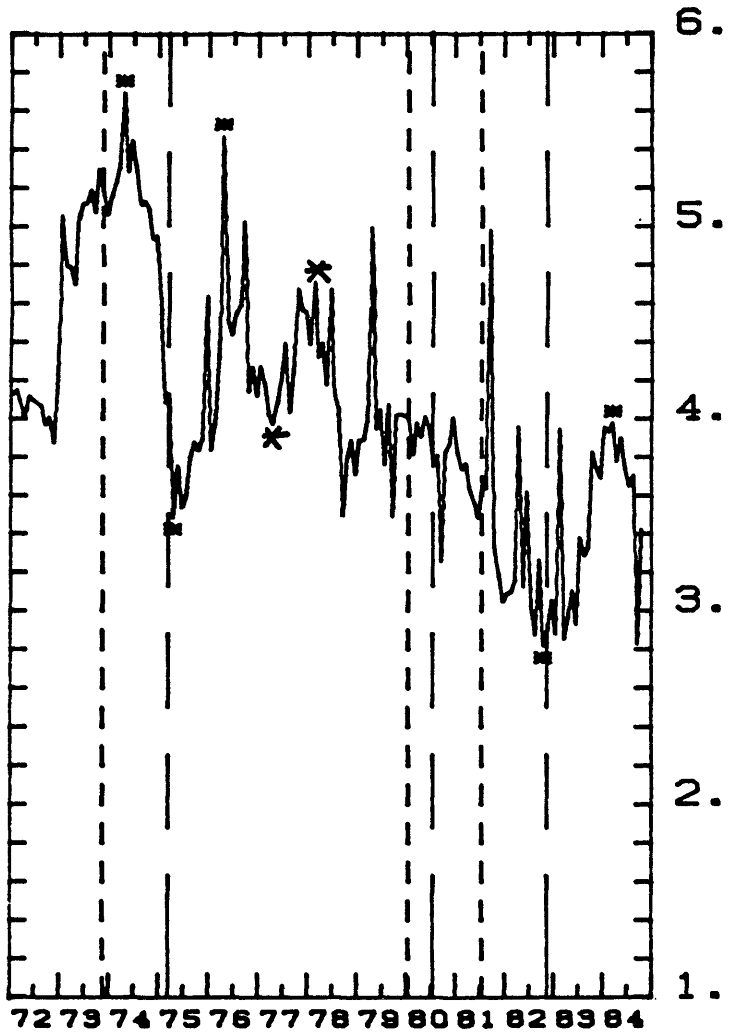


Figure B-15 Imports of Aluminum

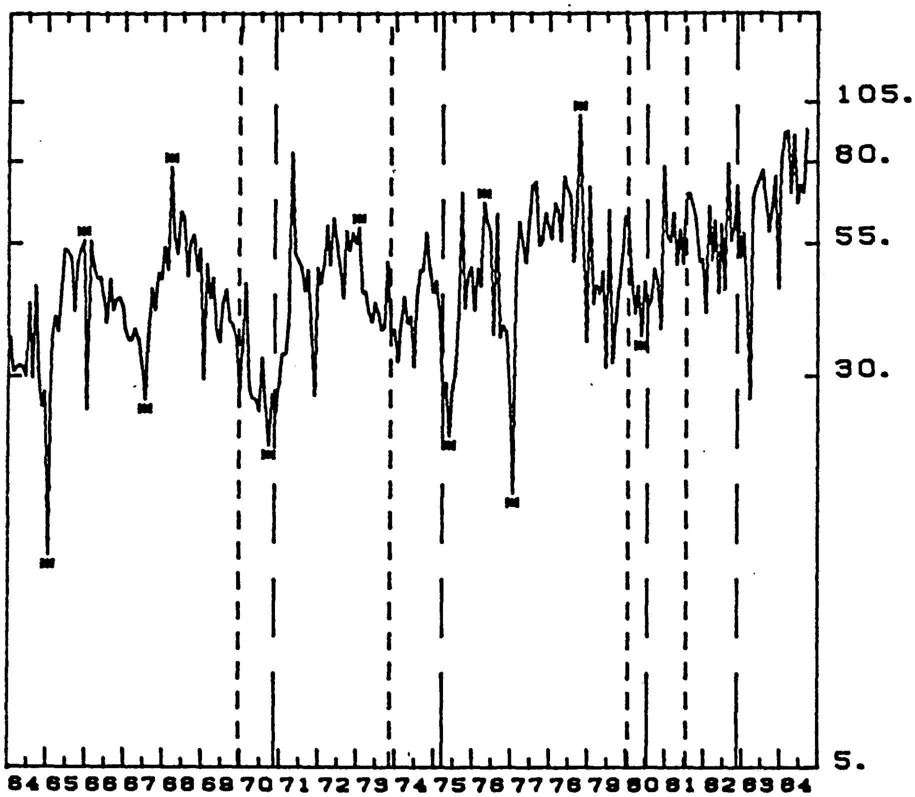


Figure B-16 Exports of Aluminum

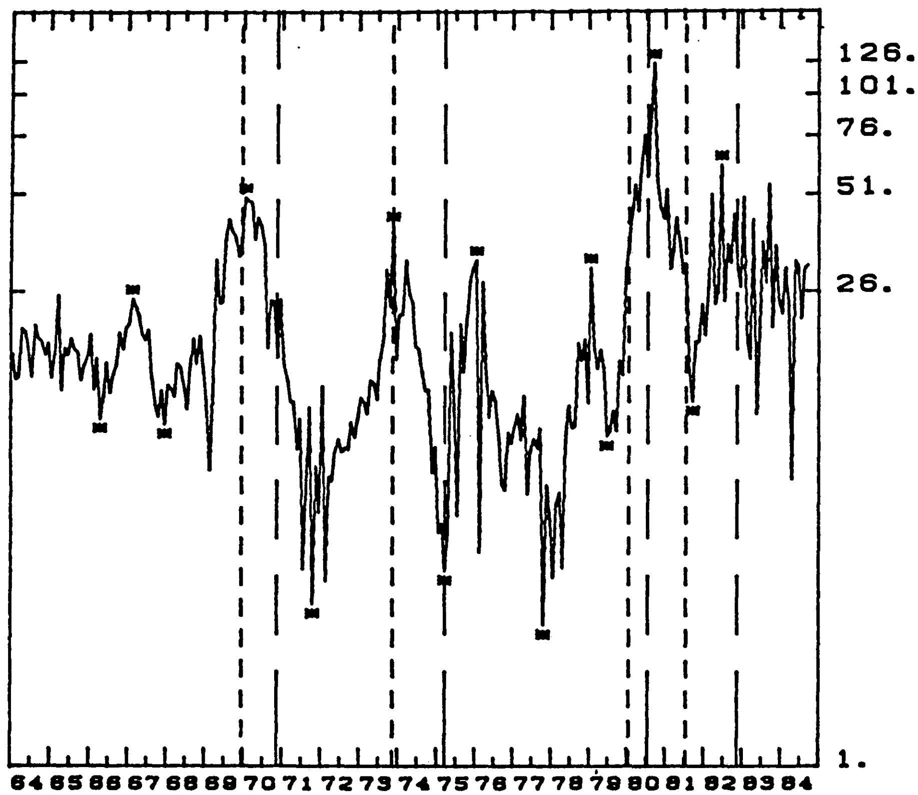


Figure B-17 Net Import of Aluminum

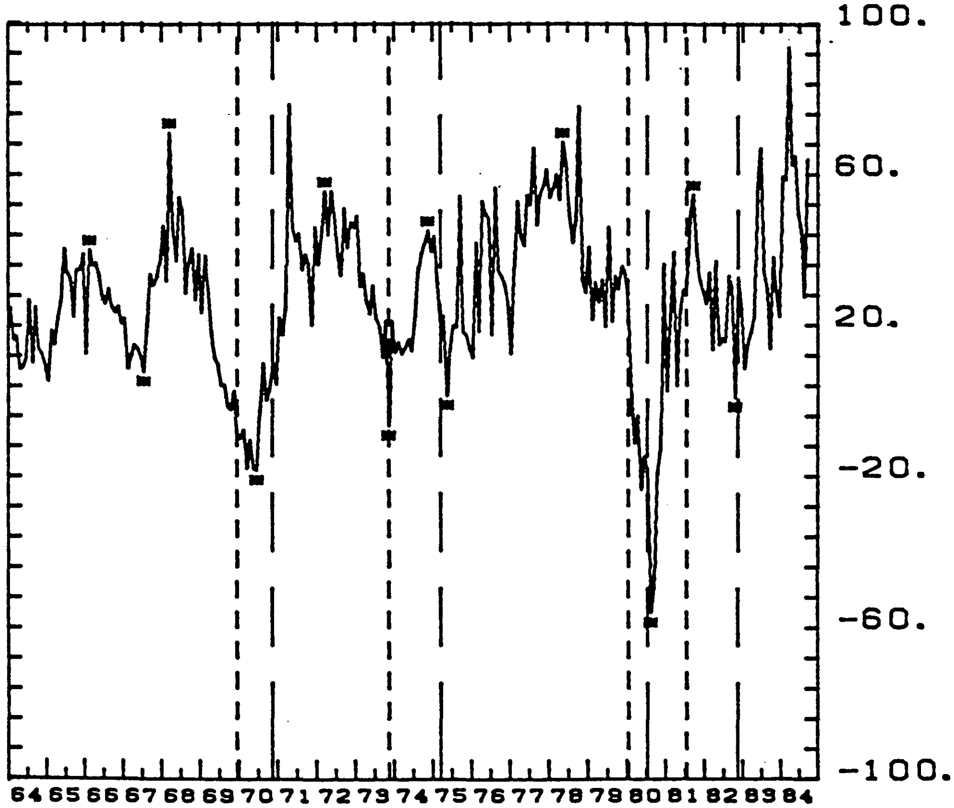


Figure B-18 Aluminum Shipments and A3LD1

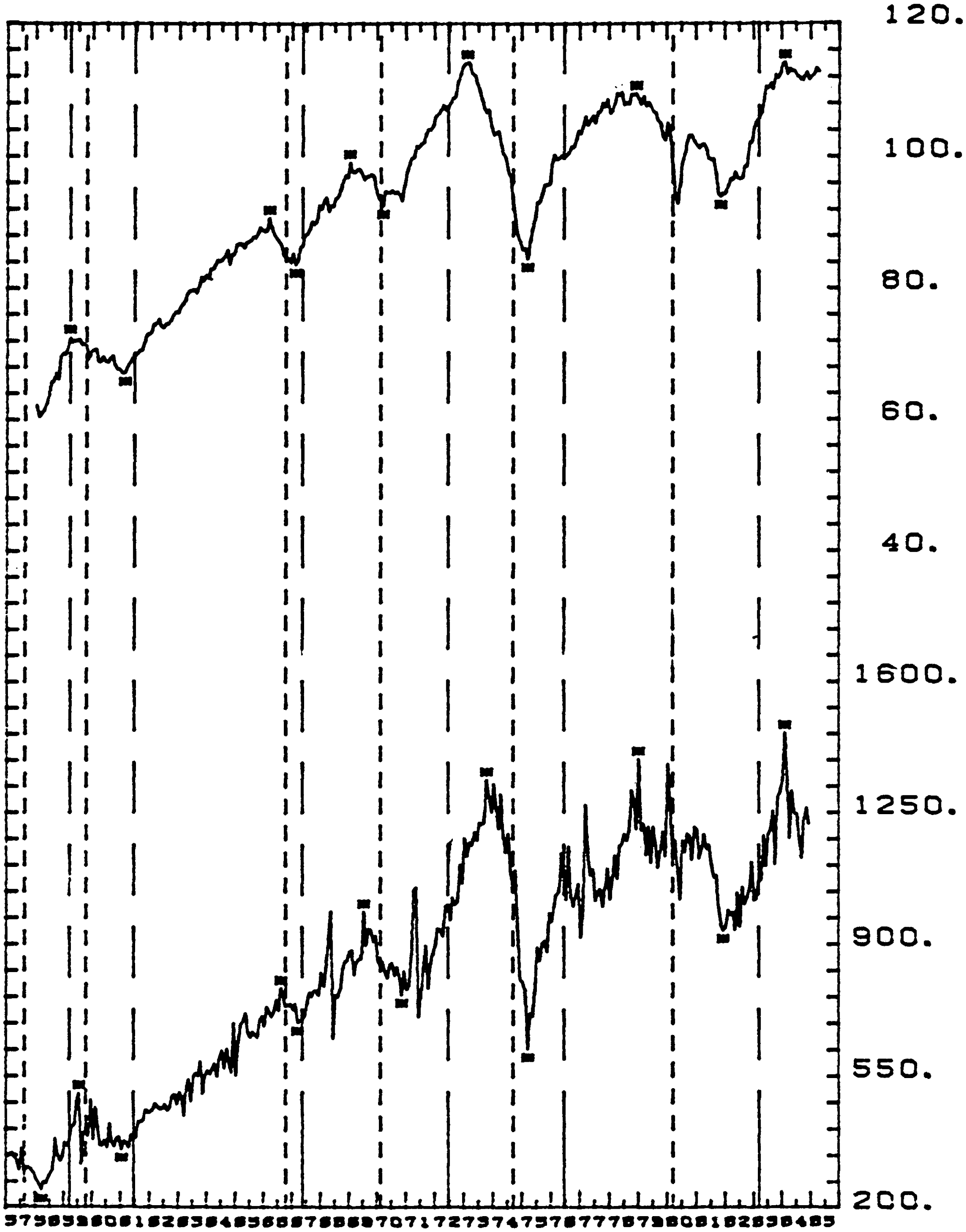


Figure B-19 Aluminum Shipments and A2LD1

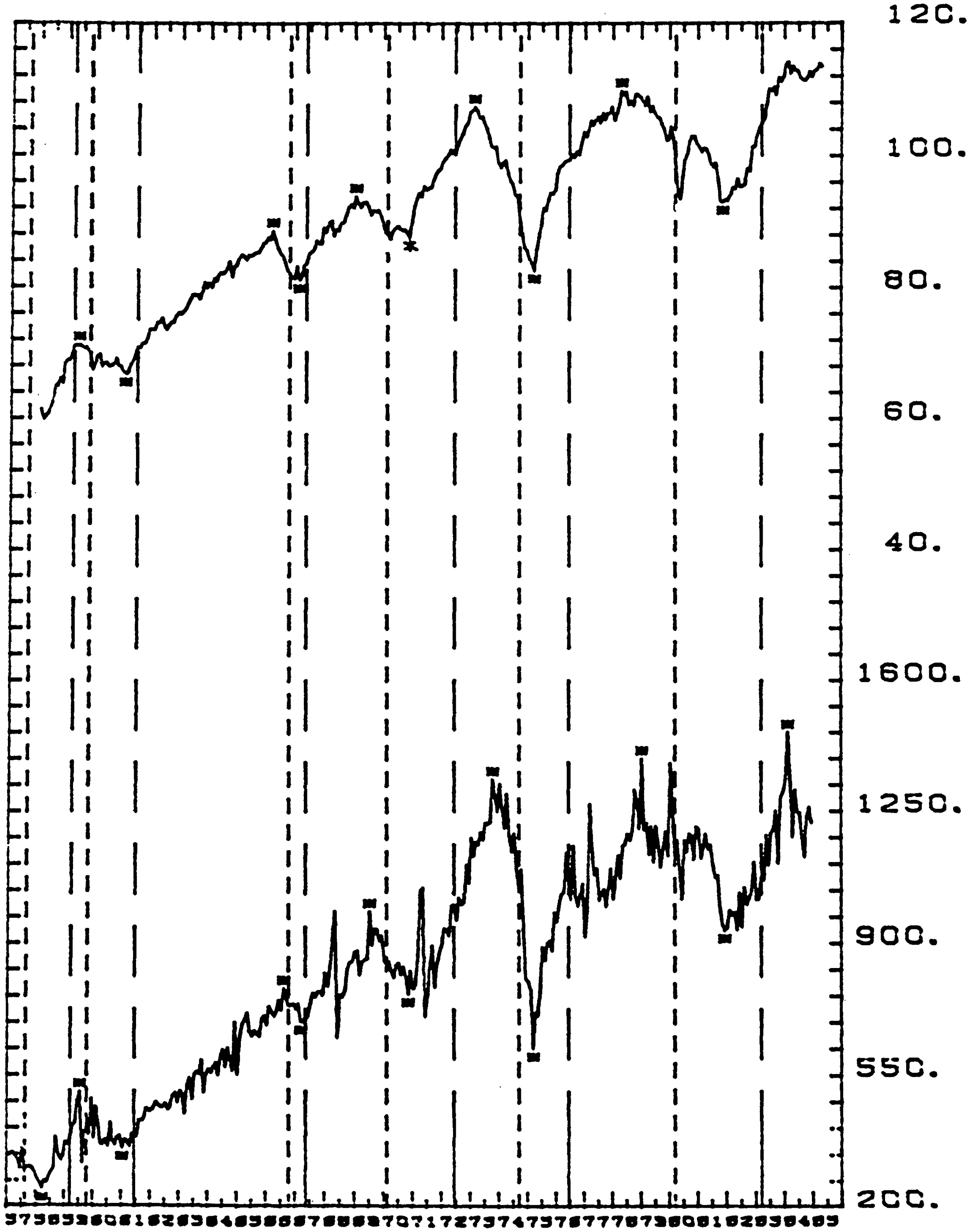


Figure B-20 Aluminum Shipments and X2LD1

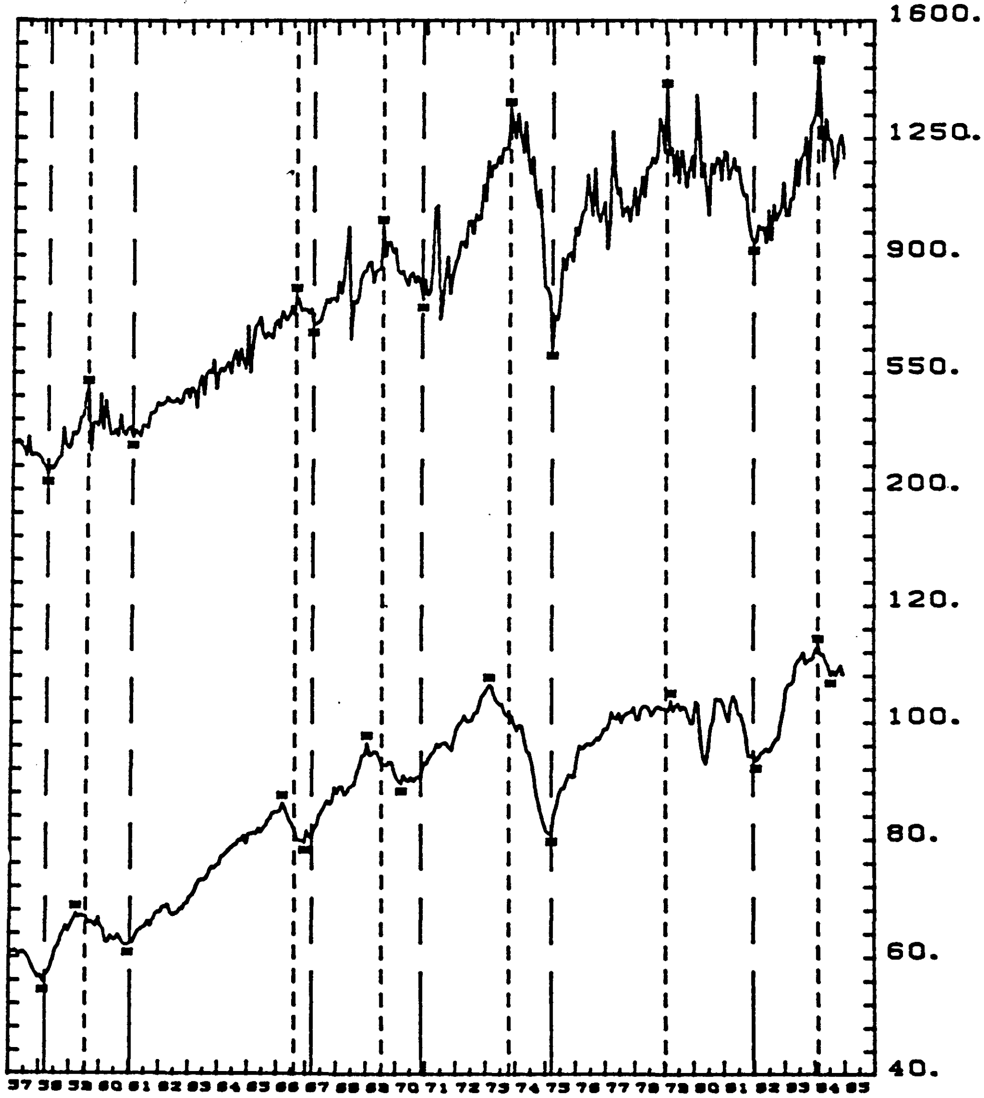


Figure B-21 Aluminum Scrap Prices and Y2LD1

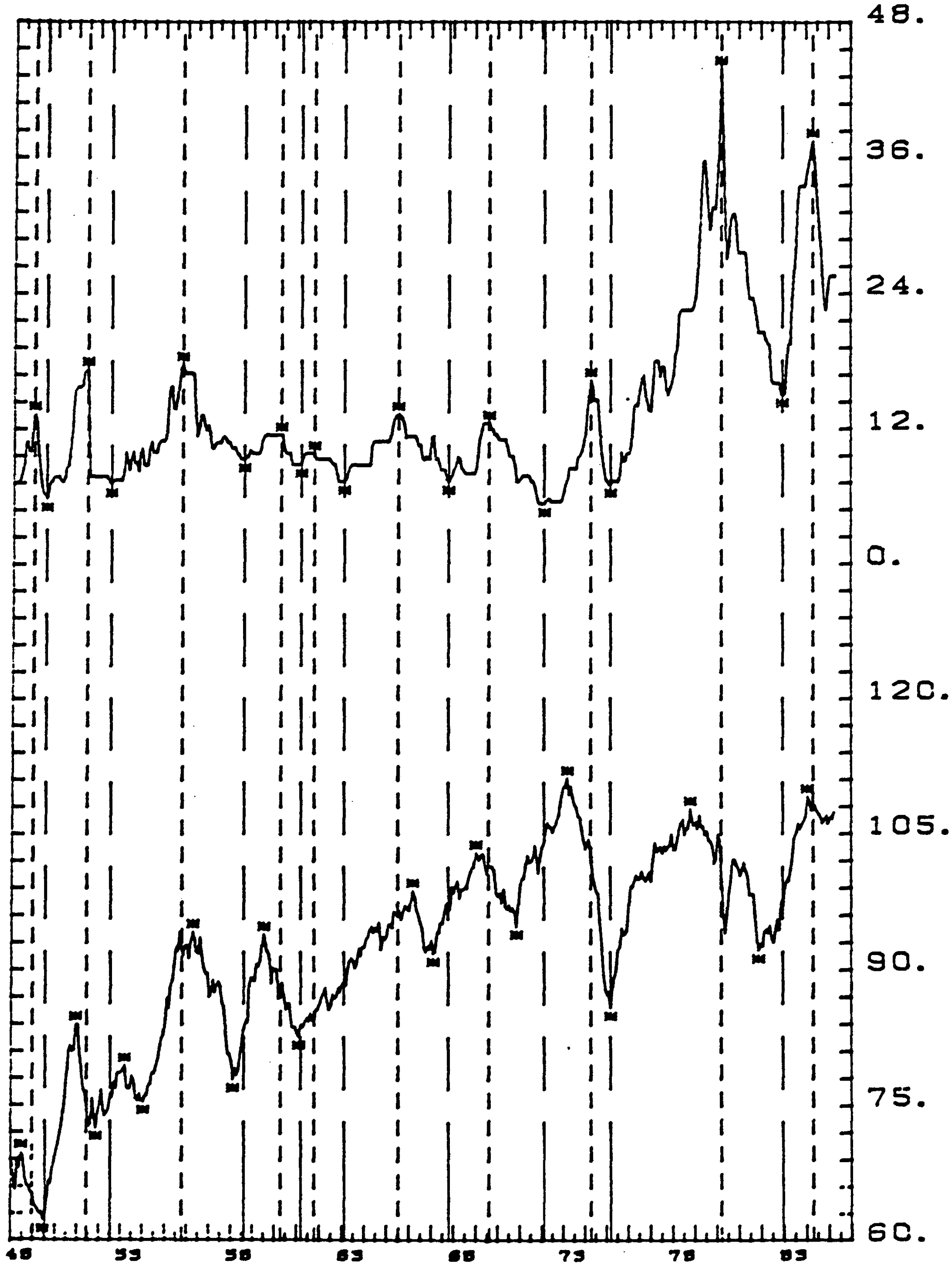


Figure B-22 Aluminum Scrap Prices and A6LD1

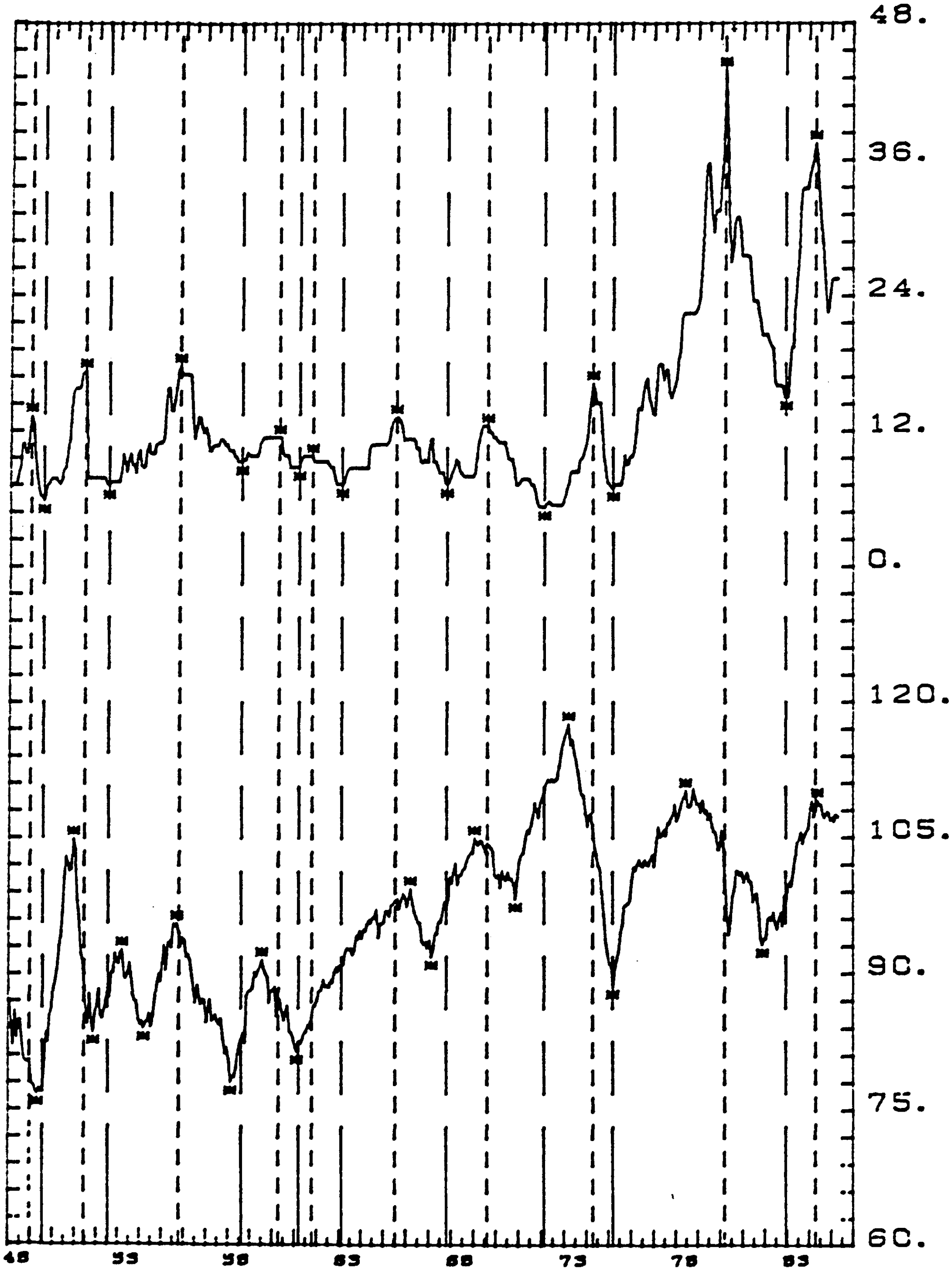


Figure B-23 Composite Leading Index vs. Aluminum Scrap Prices

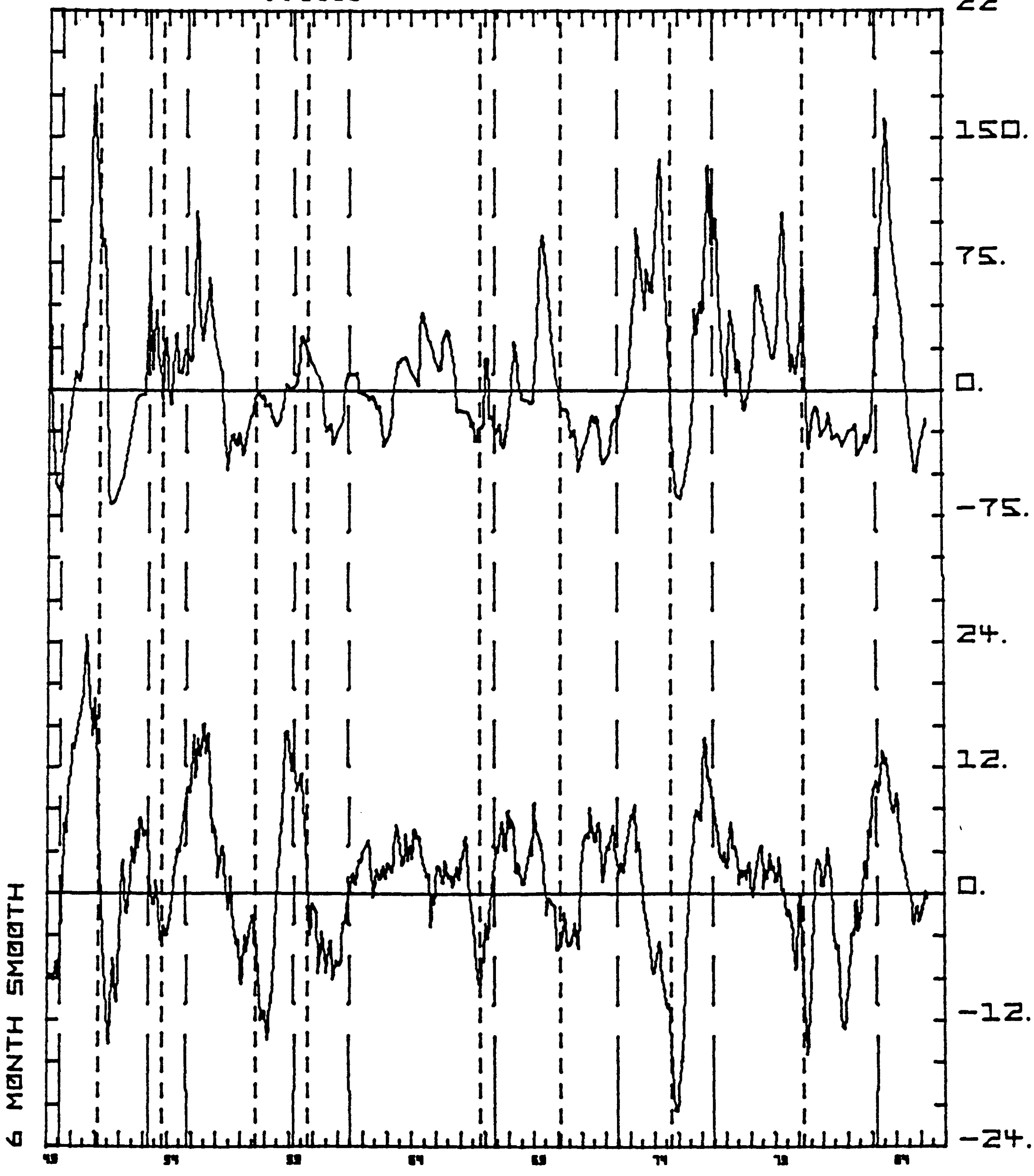


Figure B-24 SM6A5LD1 and SM6SALSHP

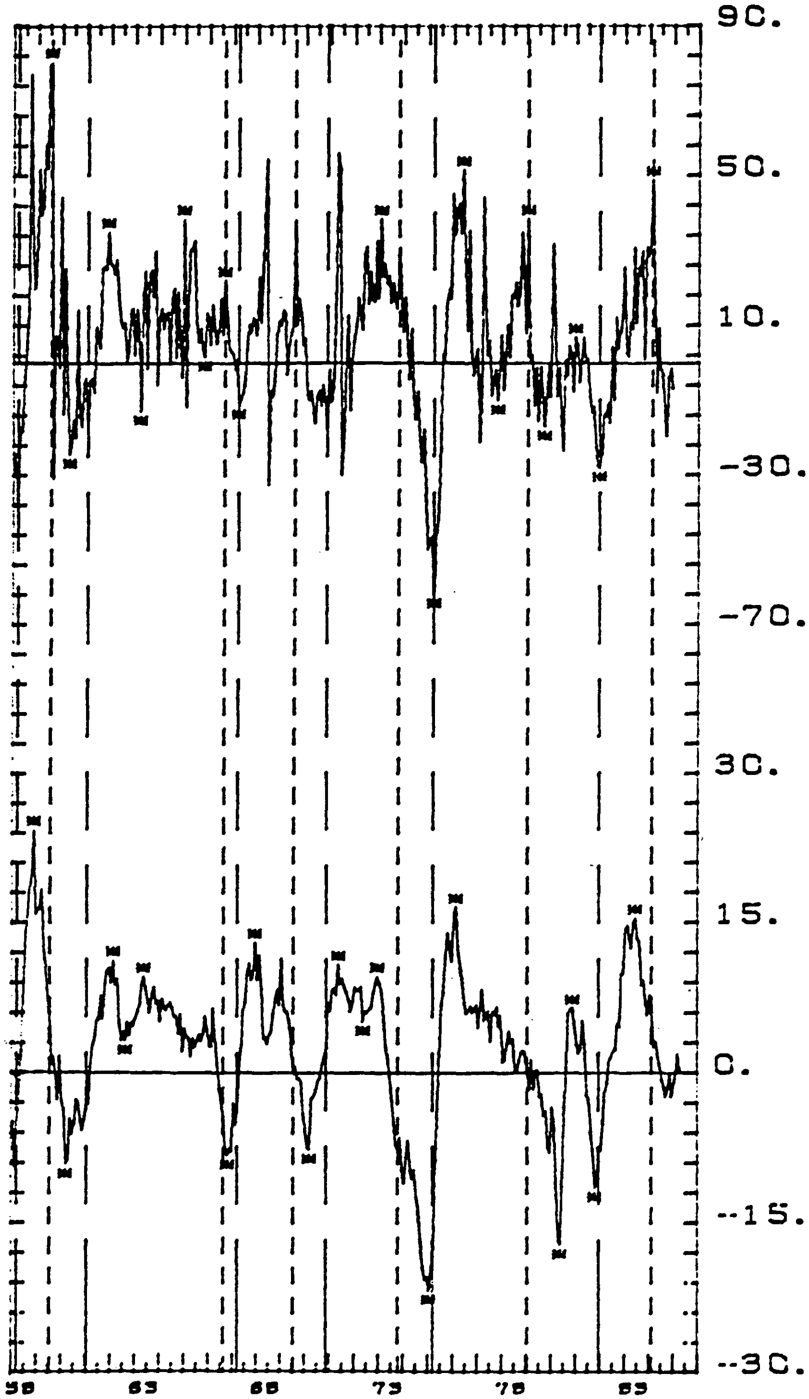


Figure B-25 SM6SALSH and SM6A2LD1