THE U.S. COPPER MARKET (1975 TO 1981): AN INQUIRY INTO PRODUCER BEHAVIOR

by

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(ABSTRACT)

It has been alleged that the major producers of refined copper in the United States have sufficient market power to enable them to "administer" their own prices. From the early 1960s until about mid-1978, the differences between producer prices and those determined in the auction markets have often been significant, but since then producer prices have followed auction prices closely.

The thesis adopts another view of producer pricing behavior; instead, it hypothesizes that the producers behave as "price takers" and trade copper at or near auction prices, either by design or because they do not have sufficient market power to do otherwise, and that they did this also in times when producer prices were significantly different from auction prices prior to mid-1978.

To test this hypothesis, an econometric disequilibrium model, based on the "short-side" methods of estimating supply and demand schedules,

is formulated to explain producer behavior for the subperiod from July 1978 to December 1981 assuming that the producers traded refined copper at auction prices. The model is then applied to the subperiod from January 1975 to June 1978 assuming that the producers traded refined copper at auction prices during this subperiod also. The coefficients of the equations in the model are then tested for equivalence between the two subperiods by means of the Chow test and a dummy variable technique in order to provide evidence in support of the hypothesis. Different behavior for the two subperiods is discovered, however, implying that producers may have been acting in response to administered prices instead of auction prices during the first subperiod.

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Chapter I

INTRODUCTION

For over three decades, the major copper producers in the United States have been quoting prices for the domestic sale of refined copper in its basic forms, such as wirebars and cathodes, that have differed from those apparent in auction markets such as the London Metal Exchange (LME) and the Commodity Exchange of New York (Comex). From the early 1960s until about 1978, the price differences have often been very significant, but since 1978 the producer prices have followed auction prices closely.

According to Gluschke, Shaw and Varon (1979), the major producers could maintain the price differentials by rationing available stocks rather than raising their "administered" prices during periods of excess demand at the quoted producer prices. Similarly, in periods of excess supply at the quoted producer prices, the producers would stock copper rather than lower prices. Gluschke et al. speculated that producers behaved this way because they would rather forego higher profits in the short run than increase the risk of copper substitution by raising prices during periods of excess demand. Consumers, in turn,

would rather forego additional savings during periods of excess supply than jeopardize the opportunity to share in rationed copper supplies at favorable prices during periods of excess demand.1/ It is therefore alleged that the producers have sufficient market power, which they have exercised through inventory policies, to enable them to trade refined copper at prices significantly different from those prevailing in the auction markets.

The purpose of this thesis is to explore whether the producers have been behaving in the manner suggested by Gluschke et al. In doing so, we will adopt a different view of producer behavior. We will suggest instead that the producers have been behaving as "price takers" and have been trading refined copper at or near auction prices, rather than at their administered producer prices. Accordingly, we will be implying that the producers have not used inventory policies as a means to administer their producer prices. We will not, however, attempt to demonstrate support for a specific cause of our suggested producer behavior apart from noting that it could arise either by design on the part of the producers or because the producers may not have sufficient market power to do otherwise.

The thesis will hypothesize, in particular, that the producers traded refined copper at or near auction prices instead of at producer prices in times when producer prices were significantly different than

auction prices prior to mid-1978. To test this hypothesis, we will take advantage of alleged changes in producer pricing policies made in mid-1978. Since then producer prices have been following auction prices closely, as is evidenced by a much stronger correlation between producer prices and Comex prices after mid-1978 than prior to that time. As will be shown in Chapter II, the correlation coefficient between the monthly average U.S. producer price of electrolytic copper, as quoted by Metals Week, and the Comex spot price of electrolytic copper, increased from 0.741 for the subperiod from January 1975 to June 1978, to 0.994 for the subperiod from July 1978 to December 1981. The changes in producer policies were announced by some of the major producers; in May 1978, for example, Kennecott Copper Corporation, one of the three largest U.S. producers, announced a change in its sales pricing policy to one directly related to daily prices established by Comex. In August 1978, the Anaconda Company followed Kennecott and announced a similar pricing policy.2/

Supply and demand theory would therefore suggest that we can formulate a model containing a set of equations to explain producer behavior for the subperiod from July 1978 to December 1981 assuming that the producers traded refined copper at auction prices. We will therefore do this and, in addition, we will apply the model to the subperiod from January 1975 to June 1978 assuming that the producers traded refined copper at auction prices during this subperiod also. (As

will be noted in Chapter II, we will not test data prior to 1975 in view of the possible existence in 1973 and much of 1974 of government pressures on the producers to hold down prices.) If we then find, as our hypothesis would suggest, that the coefficients of the two sets of equations are equivalent, the hypothesis will be supported and we will have some evidence that the producers also traded refined copper at or near auction prices prior to mid-1978 and that no structural changes have taken place. We note, however, that we will need to assume stability in the underlying forces of supply and demand during the period from January 1975 to December 1981.

We will construct an econometric disequilibrium model to explain the observed behavior of the producers assuming that they traded refined copper at the auction prices established on the Comex. The model will be formulated on the basis of the "short-side" or "Fair-Jaffee" methods of estimating supply and demand schedules in disequilibrium markets, as elaborated upon by Roger J. Bowden (1978).3/4/ Essentially, this approach assumes that if prices do not immediately clear an imbalance of supply and demand, the quantities actually transacted are determined as the minimum of the quantity demanded and the quantity supplied.

The model will include an equation to explain the producers' demand for inventories of refined copper, and also equations to explain

separately the demand of the semi-fabricating markets for refined copper, the supply of refined copper from primary sources (newly-mined copper ore), the supply of refined copper from secondary sources (scrap copper), and the demand of the U.S. market for net imports of refined copper. The inventory demand equation is particularly important. If the coefficients for this equation are equivalent for the two subperiods, this will help to indicate that the producers did not use inventory policies as a means to administer their prices during the subperiod from January 1975 to June 1978, and will therefore provide some evidence that the producers traded copper at or near auction prices during that subperiod.

Each equation will be estimated separately in its structural form on monthly average data for the two subperiods, and also for the full period from January 1975 to December 1981. Doing this will enable us to use the Chow test to test for equivalence between the sets of coefficients for the two subperiods. 5/ 6/ In addition, we will also use a dummy variable technique described by Gujarati to confirm and/or elaborate upon the results of the Chow test. 7/ We will estimate the equations for the Chow test using ordinary least squares (OLS) and, for the dummy variable approach, we will use both OLS and two stage least squares (TSLS). Although our model comprises a simultaneous system of equations, the OLS estimates are expected to provide a useful benchmark for the TSLS estimates.

The thesis, in Chapter II, will first describe the various pricing systems for refined copper and compare their behavior in recent years. Chapter III will briefly overview the copper market and industry in the United States and Chapter IV will review some earlier models of commodity markets that are of relevant interest. In Chapter V we will formulate the econometric model and, in Chapter VI, we will estimate the equations of the model. In Chapter VII we will present our summary and conclusions.

Footnotes

Chapter I

1/ Wolfgang Gluschke, Joseph Shaw, and Bension Varon, Copper: The Next Fifteen Years, D. Reidel Publishing Company, Boston, 1979, page 10.

2/ Commodity Exchange Inc., 1978 Statistical Yearbook, page 4, and American Metal Market, Metal Statistics 1979, Fairchild Publications, page 55.

3/ Ray C. Fair and Dwight M. Jaffee, "Methods of Estimation for Markets in Disequilibrium", Econometrica, Vol. 40, No. 3 (May 1972), page 497.

4/ Roger J. Bowden, The Econometrics of Disequilibrium, North-Holland Publishing Company, New York, 1978.

5/ Gregory C. Chow, "Tests of Equality between Sets of Coefficients in Two Linear Regressions," Econometrica, Vol. 28, No. 3 (July 1960), page 591.

6/ For a discussion of the Chow test and the dummy variable approach, the reader is referred to Damodar Gujarati, "Use of Dummy Variables in Testing for Equality between Sets of Coefficients in Two Linear Regressions: A Note," The American Statistician, Vol. 24, No. 1 (February 1970), page 50, and to Damodar Gujarati, "Use of Dummy Variables in Testing for Equality between Sets of Coefficients in Linear Regressions: A Generalization," The American Statistician, Vol. 24, No. 5 (December 1970), page 18.

7/ Ibid.

Chapter II

PRICING SYSTEMS FOR REFINED COPPER

London Metal Exchange

Outside of the United States and Canada, refined copper is traded primarily on the basis of price quotations established on the London Metal Exchange (LME) -- the world's largest commodity exchange on which copper is traded. The LME is primarily a paper market, since only a relatively small proportion of copper traded on the basis of LME prices actually flows through the exchange, and it is used as a hedging (or speculating) mechanism against price fluctuations by producers and semi-fabricators all over the world. It is an open market in which prices are set through simple auction twice a day. Trading on the LME is conducted for both spot delivery and for future delivery up to three months, which accords with the approximate time required for copper to be smelted and refined. Trading for delivery for longer periods into the future, however, is thought to be carried out by parties separate from the exchange but based on prices established on the LME. The LME contract system permits no pleas of force majeure. Copper is traded in the form of electrolytic wirebars and cathodes (which usually trade at a discount under wirebars, reflecting conversion costs). The contracts are specified in terms of 25 tons and multiples thereof. 1/

Commodity Exchange of New York

In the United States, the Commodity Exchange, Inc. of New York (Comex) performs functions similar to that of the LME. Trading on the Comex reflects primarily the free market in the United States, and its importance is growing. The volume of copper contracts (in units of 25,000 pounds) traded on the Comex grew at an average rate of over 43 percent annually between 1970 and 1979, reaching 2.3 million in 1979. During this same period, the average annual volume of refined copper stocks in warehouses licensed by the Comex grew at an annual rate of over 80 percent, and, in 1979, reached about 32 percent of total domestic stocks.2/ The Comex, however, is still mainly a paper market used for hedging or speculation. Actual deliveries of refined copper from the Comex ranged between approximately 340 and 400 thousand short-tons annually between 1977 and 1979, representing about 14 to 18 percent of total U.S. consumption.3/

Trading on the Comex is continuous through the working hours. Delivery of electrolytic copper can take place in any of the seven months of January, March, May, July, September, October and December, and can be specified for any one of about nine warehouses throughout the country. Daily price movement limits are set at five cents per pound advance or decline, except for spot trading for which there is no limit.4/ Comex prices are established for electrolytic cathodes (which

are about 0.6 cents per pound less than those for wirebars) for a first (spot) position (delivery in the current calendar month), a second position (delivery within the next two months), and a third position (delivery falling within a 12 month period).

Merchants

Merchants also do business in the residual market for refined copper. They usually deal in much smaller tonnages than the major producers or the commodity exchanges, thereby making themselves attractive to small-size copper customers in particular. They also sometimes carry out hedging operations on the commodity exchanges on behalf of groups of smaller customers. The merchants obtain their copper from small independent refiners or purchase it on the commodity exchanges, and often carry out arbitrage operations between the various exchanges. 5/ Merchant prices generally follow Comex and LME prices closely but at a premium.

Copper Producers

In the United States, refined copper is sold primarily by major producers who have their own marketing facilities and "administer" their own prices. A similar system operates in Canada. According to Thomas Navin, the larger copper customers buy from the producers in

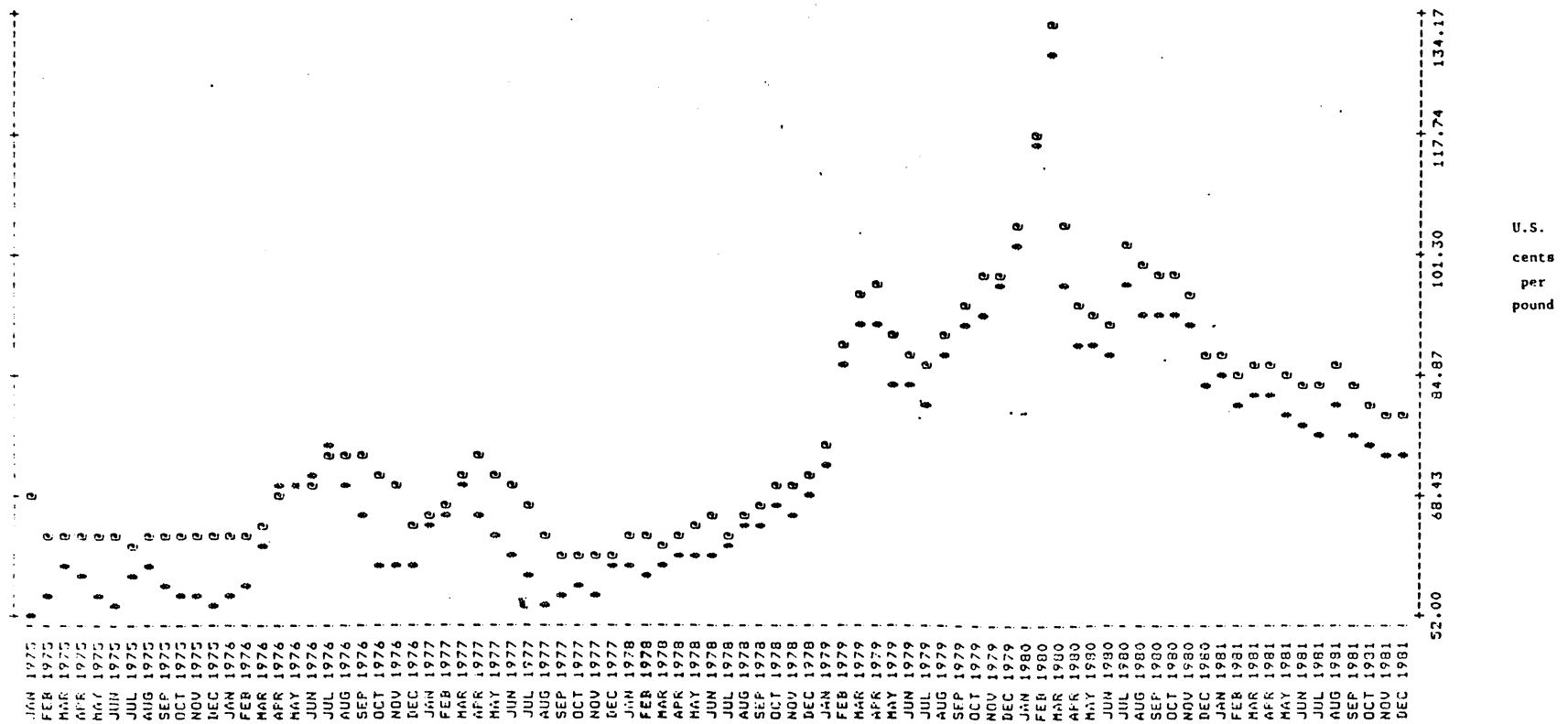
carload lots (about 50,000 pounds), and seldom for less than five carloads at a time, on the basis of annual contracts that specify the quantity of copper the customers wish to commit themselves to during the year.6/ Some producers, however, are willing to sell on a monthly basis.7/ The contracts can usually be cancelled only if specific force majeure conditions come in to play. No set price is guaranteed in the contract, but the contract often provides for delivery at a price relative to the "prevailing price" -- the average price per pound on all new contracts being signed by the major copper refiners, usually at the time of delivery. In recent years, however, some U.S. producers such as Amax Copper Inc. and Cities Service Company have given their customers the option of purchasing copper on the basis of Comex-related prices. Of particular significance, Kennecott Copper Corporation, one of the three largest U.S. producers, changed its sales pricing policy in May 1978 to one directly related to daily prices established by Comex. In August 1978, the Anaconda Company followed Kennecott and established a similar pricing policy. Both Kennecott and Anaconda indicated that they changed their pricing policies to make them more competitive with imported copper priced on the basis of LME quotations.8/ Producer prices for electrolytic copper wirebars are quoted on various bases, such as f.o.b. producer refinery, producer delivered, f.o.b. Atlantic seaboard refinery, and c.i.f. European port.

U.S. producer prices for refined copper are often higher than those on the LME and the Comex. If it is assumed that the producer prices are "actual" prices, it remains an unanswered question as to how the producers can maintain the higher prices. Various answers have been suggested, but none appear adequate. It is often said, for instance, that delivery from the producers is more predictable, and prices less volatile. In addition, although 99.9 percent pure refined copper is considered homogeneous for most purposes, semi-fabricators may prefer to purchase copper for which the impurities in the remaining 0.1 percent are known.9/ Otherwise, minor adjustments to their production processes, which involve cost considerations, may need to be made. In some periods, however, producer prices have been well below those on the Comex and the LME. Such an occurrence took place during much of 1973 and 1974 (prior to the period studied in our econometric analysis in Chapters V and VI), allegedly because of pressures from the U.S. Government to hold down prices, and/or because of pricing strategy considerations.10/

Price Comparisons

The Comex and LME prices follow each other very closely. The trading rules used by the two exchanges differ slightly, and this allows small price differences to occur. Arbitrage, however, tends to keep the prices together and hinders price differences from exceeding the costs

of moving refined copper from Europe to the United States. Scrap prices in the United States also follow closely the Comex price quotations for refined copper, since the Comex quotations generally serve as a primary reference for scrap dealers. Figure 2.1 provides a graph of monthly averages of the U.S. producer price and the Comex and LME spot prices for the period from January 1975 to December 1981. It can be seen from Figure 2.1 that, as discussed in Chapter I, the producer price began to move more closely with the Comex and LME prices after July 1978. Table 2.1 provides correlation coefficients for these prices plus the Comex futures price (second position) and the refiners' scrap price for No. 2 copper scrap for the two subperiods from January 1975 to June 1978 and from July 1978 to December 1981. The table illustrates the much higher correlation coefficients between the producer price and auction market prices in the later subperiod. For example, for the subperiod from January 1975 to June 1978, the correlation coefficient between the producer price and the Comex spot price is 0.741, while for the subperiod from July 1978 to December 1981 the coefficient is 0.994.



SOURCE: McGraw-Hill Co., New York, Metals Week, various issues.

Figure 2-1. Graph Over Time of Monthly Averages of the U.S. Producer Price and the Comex Spot Price of Electrolytic Copper

Table 2-1

Correlation Matrices of Copper Prices

A. CORRELATION MATRIX FOR MONTHLY AVERAGE PRICES FROM JANUARY 1975 TO JUNE 1978 (42 OBSERVATIONS) (U.S. cents per pound)

	PRODP 1/	PRLME 2/	PRCOM 3/	PRTWO 4/	PRTHR 5/
PRODP	1.000E+00				
PRLME	7.786E-01	1.000E+00			
PRCOM	7.407E-01	9.780E-01	1.000E+00		
PRTWO	7.362E-01	9.772E-01	9.993E-01	1.000E+00	
PRTHR	7.433E-01	9.811E-01	9.910E-01	9.921E-01	1.000E+00
SCRPR	6.364E-01	9.044E-01	9.401E-01	9.425E-01	9.458E-01

	SCRPR 6/
SCRPR	1.000E+00

B. CORRELATION MATRIX FOR MONTHLY AVERAGE PRICES FROM JULY 1978 TO DECEMBER 1981 (42 OBSERVATIONS)

	PRODP	PRLME	PRCOM	PRTWO	PRTHR
PRODP	1.000E+00				
PRLME	9.886E-01	1.000E+00			
PRCOM	9.935E-01	9.905E-01	1.000E+00		
PRTWO	9.944E-01	9.901E-01	9.985E-01	1.000E+00	
PRTHR	9.599E-01	9.397E-01	9.501E-01	9.634E-01	1.000E+00
SCRPR	9.714E-01	9.628E-01	9.706E-01	9.709E-01	9.201E-01

	SCRPR
SCRPR	1.000E+00

1/ U.S. producer price, electrolytic copper, wirebars, f.o.b. refinery.
2/ London Metal Exchange cash price, electrolytic copper, wirebars.
3/ Comex first (spot) price, electrolytic copper, cathodes.
4/ Comex second (futures) price, electrolytic copper, cathodes.
5/ Comex third (futures) price, electrolytic copper, cathodes.
6/ Refiners buying price for No. 2 copper scrap at New York.

Sources: American Metal Market, Metal Statistics; UNCTAD, Monthly Commodity Price Bulletin; and McGraw-Hill, Metals Week.

Footnotes

Chapter II

1/ Sir Ronald Prain, Copper, The Anatomy of an Industry, Mining Journal Books Limited, London, 1975, page 96.

2/ American Metal Market, Metal Statistics 1980.

3/ Commodity Exchange, Inc., Statistical Yearbook, 1977, 1978 and 1979 issues.

4/ Commodity Exchange, Inc., 1979 Statistical Yearbook, page 7.

5/ Prain, op.cit., page 96.

6/ Thomas R. Navin, Copper Mining and Management, University of Arizona Press, Tucson, Arizona, 1978, pages 88-89.

7/ Raymond F. Mikesell, ed., The World Copper Industry, The Johns Hopkins University Press, Baltimore, Md., 1979, page 82.

8/ Commodity Exchange, Inc., 1978 Statistical Yearbook, page 4, and American Metal Market, Metal Statistics 1979, Fairchild Publications, page 55.

9/ Navin, op.cit., page 81.

10/ The interested reader may refer to David L. McNicol, "The Two price Systems in the Copper Industry", The Bell Journal of Economics and Management Science, Vol. 6, No. 1 (Spring 1975), page 50, and to Mikesell, ed., op. cit., page 83.

Chapter III

OVERVIEW OF THE U.S. COPPER MARKET AND INDUSTRY

In this chapter, we will set the stage for the model construction in Chapter V by briefly overviewing recent characteristics of the copper market and industry in the United States. The U.S. copper market and industry, however, has been the subject of a number of studies during the past decade, and readers interested in a much more exhaustive treatment of the subject may refer to studies carried out by Charles River Associates (1970), Raymond F. Mikesell (1979), and Glushke, Shaw and Varon (1979). 1/2/3/

Consumption

The United States accounted for about 23 percent of world consumption of refined copper during the years from 1970 to 1979, and for about 30 percent of western consumption.4/ During this period, U.S. consumption grew at the modest pace of about 3.5 percent annually, while that of the metal's main competitor -- aluminum -- grew at about 6.3 percent annually.5/6/

Published data available for the copper consuming industries, or semi-fabricators, has been classified into six categories -- Ingot Makers, Brass Mills, Wire Mills, Foundries, Powder Plants, and Other

Industries. Other Industries include the chemical, steel and aluminum industries. The ingot makers consume refined and scrap copper and ship copper alloy ingots to the brass mills, foundries, powder plants and other industries. The brass mills, wire mills, foundries and powder plants produce copper and copper alloy products which are consumed in end-use markets. Examples of semi-finished brass mill products are sheets, plates, rods, bars, tubes, pipes and mechanical wire. Wire mills produce wires and cables for almost all purposes (but mostly electrical), and foundries produce castings of various types. In turn, the end-use markets have been classified in published data into five broad categories -- Building Construction, Transportation, Consumer and General Products, Industrial Machinery and Equipment, and Electrical and Electronic Parts.

Semi-fabricators all consume copper in either refined or scrap form except for wire mills, which consume only refined copper. During the ten-year period from 1970 to 1979, an average of about 3.1 million short-tons of copper in both forms were consumed annually. Of this, about 69 percent was refined copper, and 31 percent scrap.7/ Wire mills were the dominant consumers of refined copper (about 68 percent of the total) while brass mills were the primary consumers of scrap (about 56 percent of the total). Tables 3-1 and 3-2 illustrate the variability in U.S. consumption of both refined and scrap copper during this period, but no obvious growth trends are evident. The shares of consumption of

copper and copper alloy by the various end-use markets remained relatively stable from 1970 to 1979. Building construction, and electrical and electronic parts, were the two largest markets, accounting for about 29 percent and 25 percent of total consumption, respectively.8/

Production

Refined copper can have its origins in either newly-mined copper ore (primary sources) or scrap (secondary sources). Prior to refining, which results in copper of about 99.9 percent purity, copper ore is processed through milling and smelting stages. Copper scrap, depending upon its composition and planned use, may enter the production process at either the smelting or refining stages, or be consumed directly by semi-fabricators. Scrap is usually classified into two broad categories: (i) "new scrap" which is a by-product of the operations of semi-fabricators, and therefore largely determined by the level of current consumption; and (ii) "old scrap" which is obtained from discarded copper-containing goods and equipment.

The United States is the world's largest producer of copper ore, of blister (or smelted) copper, and of refined copper.9/ In 1979, the United States produced an estimated 1.6 million short-tons of ore,

Table 3-1

Consumption of Refined Copper in the United States by Industry
(Copper Content -- thousands of short tons)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 1/	Ten Year Average
Ingot Makers	6.8	4.5	6.0	6.1	4.7	1.6	2.9	2.5	4.0	4.2	4.3
Brass Mills	660.6	655.8	667.2	714.4	670.2	439.0	584.8	628.6	682.6	741.0	644.5
Wire Mills	1,338.7	1,324.9	1,526.3	1,672.3	1,474.3	1,061.3	1,364.0	1,511.2	1,672.7	1,656.5	1,460.2
Foundries	23.7	17.5	17.9	30.6	28.7	21.7	21.0	22.5	22.1	23.0	22.9
Powder Plants	6.5	7.2	9.5	12.7	12.0	6.8	11.8	11.3	11.5	12.0	10.1
Other Industries	14.2	11.1	10.7	12.2	9.1	9.0	8.4	13.0	24.2	21.3	13.3
	2,050.5	2,021.0	2,237.6	2,448.3	2,199.0	1,539.4	1,992.9	2,189.1	2,417.1	2,458.0	2,155.3

1/ Preliminary

Source: Copper Development Association, Inc., Annual Data 1980.

Table 3-2

Consumption of Copper Scrap in the United States by Industry
(Copper Content -- thousands of short tons)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 1/
Ingot Makers	241.4	257.9	250.5	236.7	215.0	164.0	175.7	197.2	204.1	214.0
Brass Mills	446.5	496.6	578.4	612.5	563.0	406.3	519.3	528.6	546.9	609.1
Foundries	129.7	113.4	121.7	122.7	155.4	90.9	95.7	101.2	105.2	116.3
Powder Plants	12.2	16.5	16.0	17.3	17.7	11.6	16.8	18.5	18.5	20.0
Other Industries	65.0	63.2	76.4	65.3	56.9	57.5	77.7	88.1	100.7	125.0
	894.8	947.6	1,043.0	1,054.5	968.0	730.3	885.2	933.6	975.4	1,084.4

1/ Preliminary.

Source: Copper Development Association, Inc., Annual Data 1980.

which represented about 19 percent of world production and about 24 percent of the production of western countries. U.S. ore resources are large. The U.S. Bureau of Mines has estimated the country's known resources at about 100 million short-tons, or over 63 years' production at the 1979 rate. In addition, the Bureau has predicted the existence of another 320 million short-tons of ore resources from which extraction of copper is currently or potentially feasible.10/ U.S. production of blister copper was about 1.3 million short-tons in 1979, or about 15 percent of world production and about 19 percent of western world output. Production of refined copper in that year was estimated at 2.2 million short-tons, or about 21 percent of world production and 28 percent of the total from western countries.11/

As shown in Table 3-3, wide fluctuations in U.S. production of refined copper were experienced during the period from 1970 to 1979, but no long-term growth trends are apparent. Increasing levels of production, however, are noticeable in the later years, as is an increased use of scrap. Secondary production of refined copper also appears to have been increasing relative to primary production in recent years. Table 3-3 also illustrates the importance of secondary production of refined copper which, in 1979, accounted for about 26 percent of total production.

Table 3-3

Sources and Production of Refined Copper in the United States
(Copper Content, thousands of short tons)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 1/	Ten-Year Average
Domestic Production:											
(i) from Primary Sources 2/	1765.1	1591.8	1873.2	1868.5	1654.7	1443.4	1539.3	1496.2	1597.3	1670.4	
(ii) from Secondary Sources	477.6	370.6	385.3	444.1	483.9	331.5	351.2	352.4	504.1	600.7	
(a) Scrap at Smelters	(78.9)	(66.3)	(69.0)	(77.8)	(79.5)	(49.4)	(51.0)	(49.4)	(59.8)	(66.4)	
(b) Scrap at Refiners	(398.7)	(304.3)	(316.3)	(366.3)	(404.4)	(282.1)	(300.2)	(303.0)	(444.3)	(534.3)	
Total Domestic Production	2242.7	1962.4	2258.5	2312.6	2138.6	1774.9	1890.5	1848.6	2101.4	2271.1	
Secondary Production as % of Total	21.3	18.9	17.1	19.2	22.6	18.7	18.6	19.1	24.0	26.4	20.6
Total Production as % of Consumption (refer Table 3-1)	109.4	97.1	100.9	94.5	97.3	115.3	94.9	84.4	86.9	92.4	97.3

1/ Preliminary
2/ Primary sources include copper ore and blister copper plus imports of ore and blister and drawdowns from stocks.

Source: Copper Development Association, Annual Data 1980.

The United States is largely self-sufficient in copper. Net imports of ore averaged only about 1.6 percent of total ore inputs annually from 1970 to 1979.12/ Net imports of blister copper averaged about 6.4 percent of the total blister inputs during this same period.13/ At the refining stage, domestic production of refined copper accounted for an average of about 97 percent of refined copper consumption (Table 3-3). The United States is a net exporter of scrap; an average of about 5 percent of scrap receipts were exported annually from 1970 to 1979.14/

Structure of the Copper Industry

The copper producing industry in the United States is highly concentrated. In 1978, three companies -- ASARCO,15/ Kennecott and Phelps Dodge -- owned or controlled almost 65 percent of domestic mine production, and owned about 73 percent of the country's total smelter capacity and 60 percent of its major refinery capacity (Table 3-4). In addition, seven companies were fully integrated from mining through smelting to refining, and had their own marketing facilities. Together they owned or controlled the bulk of domestic mine production, and about 97 percent of total smelter capacity and 86 percent of total refinery capacity.16/ Of the seven integrated companies, the most recent to be established was the Newmont Mining Corporation in 1916.17/18/ Kennecott and Inspiration were the only others of the seven to be established in

Table 3-4

Major Copper Producers and Marketers in the United States, 1978 1/

Company	Total U.S. Mine Production (short tons)	Annual Smelting Capacity (short tons of material)	Annual Refining Capacity (short tons)		Marketing Facilities
			Electrolytic	Lake and Fire Refining	
ASARCO	333,994 2/	2,136,000	744,000		Yes
Anaconda 6/	142,776	750,000	252,000		Yes
Anamax 7/	100,536				
Cities Service	90,839	18,000			Yes
Copper Range	40,673	90,000 (est.)		90,000	Yes
Cyprus	70,653				
Duval	124,013				Yes
Inspiration 8/	39,688	450,000	70,000		Yes
Kennecott	318,226 (U.S. mines)	1,975,000	467,000	103,000	Yes
Magma (Newmont) 9/	156,107 2/	800,000	200,000		Yes
Phelps Dodge	319,000 (U.S. mines)	2,490,000	492,000	45,000	Yes
Quincy Mining		15,000 (est.) 4/		15,000	Yes
AMAX 10/	197,695 3/	193,000	191,000	103,000	Yes
Chemetco		150,000	40,000		
Cerro			44,000	61,000	Yes
Southwire			72,000		
Essex				37,500	
General Cable				38,000	
Reading Industries				40,000	
Cominco American	2,211				
Hecla Mining	593				
Idorado Mining 12/	574				
Ranchers-Exploration and Development	6,198				
Ametalco					Yes
Totals	1,487,236 11/	9,067,000	2,572,000	532,500	
				3,104,500	

1/ Excludes a number of small mining companies, and also a small number of minor smelting and refining companies that process primarily scrap.
2/ Includes 222,845 short-tons of other producers in which ASARCO has interests and 111,149 of its own production.
3/ Measured as refined production.
4/ The tonnage represents AMAX's interests in the output of other producers.
5/ Closed.
6/ Owned 20 percent by Inspiration Consolidated.
7/ Owned 50-50 by AMAX and Anaconda.
8/ Owned partially by Anaconda.
9/ Wholly owned by Newmont Mining Corporation.
10/ Owned 20 percent by Copper Range.
11/ Total domestic ore production in 1978 was about 1,496,000 short-tons (refer Table 2-4).
12/ 80.1 percent owned by Newmont Mining Corporation.

Source: American Bureau of Metal Statistics, Non-Ferrous Metal Data 1978.

the twentieth century. In 1978, refinery capacity in the United States appeared to be underutilized; available capacity exceeded actual production by almost 50 percent, and exceeded actual consumption by about 30 percent.

A number of the major copper refiners, including the three largest, are also integrated into the semi-fabricating industry, but this industry appears to be much less concentrated. In 1967, there were well over one hundred companies, most of which were unrelated to the major refiners, producing semi-fabricated products.19/ Various sources, however, have estimated that the major copper producers control between a third and a half of the country's semi-fabricating capacity.20/ The scrap industry, which supplied semi-fabricators with over 30 percent of their copper needs during the period from 1970 to 1979, and smelters and refiners with over 20 percent, is made up of a large number of collectors, and is therefore relatively unconcentrated.

The US copper industry is often considered to pose signficant barriers to new entrants. J.S. Bain (1956) considered the barriers to be substantial -- primarily scale economies and capital costs -- and increased as one progressed from mining through smelting to refining.21/ In addition, since the country's present refining capacity exceeds the level of domestic consumption of refined copper, potential entrants would be placed in a disadvantaged position relative to

existing refiners. At the semi-fabricating level, the barriers to entry are less substantial, since economies of scale and capital costs do not play as significant a role as in smelting and refining.

Competing Materials to Copper

Copper faces competition from a number of materials such as aluminum in electrical applications, plastics in plumbing applications, and stainless steel in food processing and other applications where resistance to corrosion is an important factor. Today the most significant competitor is thought to be aluminum, and both metals compete particularly in some subsectors of the electrical market. While aluminum's electrical conductivity is only about 61 percent of copper's on a volume basis, its weight for a given volume is less than one-third of copper's, and this has helped to ensure the dominance of aluminum in the construction of high voltage power transmission lines. A picture of the competitive performance of the two metals in the subsector of the electrical market in which wire mill products compete is given in Table 3-5. Aluminum products in this subsector accounted for about 11 percent of total consumption during the 1970s. Although no longer-term gains by the lower priced aluminum products are evident, the apparent decline in the ratio of the producer copper price relative to the producer aluminum

Table 3-5

Comparison of Copper and Aluminum Wire Mill Outputs
(thousands of short-tons)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Ten-Year Average
1. Aluminum Wire Mills[1/]	138.0	167.5	194.0	232.5	233.5	128.0	157.0	193.5	214.5	219.5	188.0
2. Copper Wire Mills	1338.7	1324.9	1526.3	1672.3	1474.3	1061.3	1364.0	1511.2	1672.7	1656.5	1460.2
Total Output	1476.7	1492.4	1720.3	1904.8	1707.8	1189.3	1521.0	1704.7	1887.2	1876.0	1648.2
3. Aluminum as a % of Total	9.3	11.2	11.3	12.2	13.7	10.8	10.3	11.4	11.4	11.7	11.4
4. Aluminum Producer Price[2/]			21.1	26.4	43.1	34.8	41.1	47.8	51.0	70.7	
5. Copper Producer Price[3/]	57.7	51.4	50.6	58.9	76.6	63.5	68.8	65.8	65.5	92.3	
6. Ratio of Copper Price to Aluminum Price			2.4	2.2	1.8	1.8	1.7	1.4	1.3	1.3	

1/ Net Shipments of Aluminum insulated wire and cable and bare wire (excludes high voltage transmission wire).
2/ Aluminum 99.5% Ingots, U.S. Market; according to Metals Week.
3/ Electrolytic Copper, Wirebars, U.S. Producer f.o.b. refinery; according to Metals Week.

Sources: The Aluminum Association, Inc., Aluminum Statistical Review 1979;
Copper Development Association, Inc., Annual Data 1980.

price suggests that copper substitution may have been forestalled by an erosion in relative prices.

Market Powers of the Major Producers

As explained in Chapter I, Gluschke, Shaw and Varon (1979) have suggested that the major producers of refined copper in the United States may have the capability to exert considerable market power. Indeed, the high degree of concentration in the copper industry would seem to lend support to this view. A number of factors, however, could possibly act to constrain their power. Domestically, for example, there is the residual auction market for copper which could possibly be fed by non-integrated producers utilizing an ever-rising pool of scrap, and also competition from substitute materials. In addition, the major producers could face significant competition from imports, since the costs of importing refined copper appear to be relatively low. A measure of transport costs, for instance, can be made by comparing the producers' f.o.b. Atlantic seaboard refinery price with their c.i.f. European port price. The difference has recently been about 4.2 cents per pound, or about 5 percent of the average Comex spot price in 1981. Import duties are also low. The rate of duty on copper wirebars in recent years has been 1.5 percent ad valorem.22/

Footnotes

Chapter III

1/ Charles River Associates, Inc., Economic Analysis of the Copper Industry, General Services Administration, Washington, D.C., March 1970.

2/ Mikesell, ed., op.cit.

3/ Gluschke, Shaw and Varon, op.cit.

4/ American Metal Market, Metal Statistics 1980, pages 34 and 35.

5/ Copper Development Association, Inc., Annual Data 1980.

6/ The Aluminum Association, Inc., Aluminum Statistical Review, 1979, page 10.

7/ Copper Development Association, Inc., op.cit.

8/ Ibid.

9/ Metallgesellschaft AG, Metal Statistics 1969-1979, Frankfurt Am Main, 1980.

10/ Copper Development Association, Fact Sheet, May 1980.

11/ Metallgesellschaft AG, op.cit.

12/ Copper Development Association, Annual Data 1980.

13/ Ibid.

14/ Ibid.

15/ American Smelting and Refining Company.

16/ Excluding a few small smelting and refining companies.

17/ As the Newmont Company.

18/ Standard and Poor's Corporation Records.

19/ Metal Bulletin Books, Ltd., Non-Ferrous Metal Works of the World, First Edition, London, 1967.

20/ Refer to, for example, Mikesell, ed., op.cit., pages 31 and 108.

21/ J.S. Bain, Barriers to New Competition, Harvard University Press, Cambridge, Mass., 1956, page 192.

22/ Metal Bulletin Ltd., Metal Bulletin Handbook 1980, Surrey, U.K., page 886.

Chapter IV

REVIEW OF SELECTED ECONOMETRIC MODELS

Since 1970, a number of econometric models of commodity markets, including the copper market, have been discussed in the literature. Here we shall briefly review, in chronological order, four selected works which either relate to the copper market or have entailed the use of disequilibrium models.

Charles River Associates (1970)

Charles River Associates, Inc. (1970) modelled the U.S. demand for refined copper and the formation of copper prices. 1/ They formulated their model to explain domestic copper consumption, the supply of copper and an administered "price" of copper that was a weighted average of the primary (or producer) price of refined copper, the price of scrap, and the LME price of refined copper. Their model includes equations for the domestic demand for copper inputs, fabricators' inventories and net exports of refined copper, and equations for the supply of primary copper, producers' inventories, and old and new scrap. It allows for disequilibrium partly by means of an equation for the price of scrap in which the scrap price depends upon

both the producer price and excess demand, where excess demand is computed as the difference between total demand and total supply. If demand exceeds supply at the current scrap price and producer price, then the scrap price rises. The demand equation also allows for disequilibrium, since it is based on a partial adjustment mechanism of the form

$$Q_t - Q_{t-1} = u\,(Q^*_t - Q_{t-1}) \qquad 0 \leq u \leq 1 \qquad (4\text{-}1)$$

where Q is the demand for copper and Q* is long-run equilibrium consumption. In addition, the model incorporated a partial adjustment equation for the producer price.

Charles River Associates made two general postulates regarding producer pricing: (1) the producer price is an "administered" price reflecting the producers' expectations regarding levels of demand and costs; and (ii) the producers follow a policy of price stability under which they adjust the producer price only partially within a single period to any change in their desired price level. This pricing behavior is then reflected in producer production and inventory behavior under which producers would plan production to be consistent with their "administered" price and attempt to trade refined copper at that price irrespective of market demand. In addition, the producers would attempt to satisfy consumer demand before attempting to meet their own demand

for inventories. The actual change in inventories, therefore, would equal the difference between the quantity demanded at the producer price, and production.2/3/

Charles River Associates estimated their model with the Hildreth-Lu procedure using annual data for the years 1949 to 1966 and with the producer price as the price variable.4/ (In our model, we will be using the Comex price). Their results led them to conclude that:

(i) the demand for refined copper was relatively insensitive to price in the short-run (within one year) but very responsive in the long-run;

(ii) the demand for copper was inelastic with respect to the price of aluminum in the short-run but very elastic in the long-run;

(iii) the effect of the level of scrap prices on the level of total demand for copper might be small;

(iv) net exports were not very responsive to differences between domestic and foreign prices of copper, but were strongly influenced by the level of economic activity in the United States relative to that abroad; and

(v) the supply of old scrap was price inelastic.5/

As will be seen later, our analysis will lead to similar conclusions with respect to the behavior of the demand for copper in the short-run.

Fisher, Cootner and Baily (1972)

Franklin M. Fisher, Paul H. Cootner and Martin Neil Baily (1972) formulated an econometric model of the world copper industry that incorporates supply equations for the major producing countries and demand equations for each of the principal consuming areas.6/ They constructed their model assuming that refined copper in the United States trades largely at the U.S. producer price while most of the remaining refined copper in the world trades at the LME price. Their postulates in respect of producer pricing behavior are similar to those of Charles River Associates.

In particular, they postulated that the U.S. producers "set the U.S. producer price to reflect what they believe to be a sustainable (and profitable) long-run level of copper prices, taking into account their own resulting supply decisions. Believing it in their interest to have a relatively stable price, they then take that price as given for the time being and decide on the amount of copper they will supply at that price."7/ The postulates of Fisher et al. regarding inventories are

also similar to those of Charles River Associates. Fisher et al. considered that "the difference between U.S. total copper consumption and U.S. available supplies (primary, secondary, and imports) is the change in U.S. inventories. If inventories tend to increase for some period of time and the LME price is below the U.S. producer price, then producers gradually conclude that they set too high a price and the proper "long-run" price is below the U.S. producer price. On the other hand, if inventories are being depleted over some period of time and the LME price is well above the U.S. producer price, then the producers gradually conclude that the proper "long-run" price is above the U.S. producer price. They then readjust the U.S. producer price in the indicated direction and the process begins again."8/

The authors also suggested that consumers in the U.S. take price as a given. For example, if the producer price is below those in the auction markets, which was often the case in the late sixties and early seventies, consumers who are not able to buy refined copper at the producer price will tend to import refined copper or purchase scrap for refining.

Fisher et al. speculated how U.S. producers could maintain significant price differentials between the producer price and the LME price. They noted that when the U.S. producer price was substantially below the LME price, a high degree of arbitrage did not take place. They

therefore presumed that the producers' favored customers were unwilling to jeopardize their long-run relations with the producers for the sake of short-run gains from arbitrage, even though the producers might ration their sales. The authors also presumed that the producers could discover fairly readily if a large customer was reselling on the LME.

The authors also speculated why U.S. producers would behave this way and not attempt to reap short-run returns by raising the producer price. They suggested that speeds of adjustment in the copper industry are very low, and that there are long lags on both the demand and supply sides of the market. Price elasticities of demand and supply would therefore both be much higher in the long-run than in the short-run, leading to a situation where exogenous factors could easily raise short-run market-clearing prices considerably while the long-run equilibrium price remains relatively unaffected. The producers may therefore hesitate to raise prices for fear of triggering customers to begin costly changeovers from copper to aluminum-using equipment. Moreover, the producers may ration only customers who could not switch or for whom the cost of switching is low. In addition, producers may fear that raising the producer price to the short-run market-clearing level could be taken as a signal by potential new copper producers that the long-run price, and therefore profits, are rising, thereby possibly generating unwanted new capacity in the industry.9/

Fisher et al. formulated the equations in their model in terms of partial adjustment processes as applied to quantities. To illustrate this method, the authors suggested as an example that the producers of primary copper in a hypothetical country might like to supply an amount S^*_t, which depends on the price P_t received by the producers according to the long-run supply equation

$$S^*_t = a + b\ P_t \qquad (4\text{-}2)$$

Since it takes time to adjust supply, the producers would not adjust immediately to a new value for S^*_t in response to a new value for price, but only begin to adjust. In other words,

$$S_t - S_{t-1} = u(S^*_t - S_{t-1}) \qquad 0 \leq u \leq 1 \qquad (4\text{-}3)$$

where u is the fraction they could adjust in a given period of time. Substituting equation 4-3 into equation 4-2 gives

$$S_t = ua + ubP_t + (1-u)S_{t-1} \qquad (4\text{-}4)$$

Equation 4-4 could also be lagged to obtain an expression for S_{t-1} which could then be substituted back into the equation. Doing this repeatedly would yield

$$S_t = a + ub \sum_{\theta=0}^{\infty} r^{\theta} P_{t-\theta} \qquad (4-5)$$

where $r = 1-u$. 10/

In their equations for the United States, the authors used the "Engineering and Mining Journal (EMJ)" estimate of the producer price of electrolytic refined copper for their price variable. The EMJ price, as the authors noted, is a weighted average of the U.S. producer price and the LME price, with the U.S. producer price receiving more than 97.5 percent of the weight.11/ The authors considered this price to reflect the price at which copper is actually traded in the United States more accurately than the U.S. producer price.

Fisher et al. estimated the equations in their model using an instrumental variables technique on annual data covering the period from about 1949 to 1968. They concluded generally that the world copper market is characterized by relatively inelastic demand and very high elasticity of supply in the long-run, a low adjustment speed, and relatively low short-run elasticities of both supply and demand. (Their conclusions are therefore similar to those of Charles River Associates and, as will be seen later, we will also reach similar conclusions with respect to the short-run elasticities of supply and demand). Altogether, this would lead to a weak tendency for price to approach a long-run equilibrium, and for a relatively unstable short-run price that is

sensitive to changes in general economic conditions. They noted that the latter was truer of the LME price than of the U.S. producer price, whose fluctuations were deliberately reduced by the producers. They perceived the main actor in creating this price instability to be the inherent stock accumulation process.12/

B.T. McCallum (1974)

B.T. McCallum (1974) formulated alternative models of a competitive price adjustment process for the U.S. lumber industry, which he noted to be highly atomistic.13/ In doing so, he attempted to shed light on the relative merits of models that explicitly recognized inventory holdings relative to those that did not. He based his models on the theoretical proposition that price changes in continuous time depend upon excess demand, or

$$\frac{dp}{dt} = F[d(P) - S(P)] = F[E(P)] \qquad (4\text{-}6)$$

where P is price, D is demand, S is supply, and E is excess demand. He reformulated this equation for discrete-time to obtain

$$P_t - P_{t-1} = k\, E_t \qquad (4\text{-}7)$$

where P_t and E_t denote, respectively, the (average) price and excess demand during period t. k is a positive constant.

In the models recognizing inventory holdings, he postulated equations for demand, production (instead of supply) and optimal inventory holdings. He then made use of equation 4-3 and the market-clearing condition

$$D_t = Q_t + I_{t-1} - I_t \qquad (4\text{-}8)$$

where D is demand in period t, Q_t is production in period t, and I_{t-1} and I_t are inventories in periods t-1 and t respectively, to obtain an expression for P_t. His equations for optimal inventory holdings were based on the supply of storage theory 14/ and varied depending upon his assumptions regarding the formation of price expectations. He tested his models using a number of alternative assumptions, including adaptive expectations.

McCallum obtained ordinary least squares estimates for his alternative P_t equations using quarterly data for the years 1958-69. The results suggested that "price adjustment models based on supply of storage inventory theory, besides being theoretically more explicit and complete, are empirically superior to the inventory-free specifications provided by the law of supply and demand."15/

E.C. Hwa (1979)

E.C. Hwa (1979) constructed stock disequilibrium models of price adjustments in competitive markets for various commodities, including copper and other metals traded on the LME.16/ One of his objectives was to test whether the marked fluctuations in the prices of primary commodities traded in international markets could be well-explained by systematic variations of demand and supply. A second objective was to shed light on the nature of the price determination mechanisms for primary commodities in general; in particular, whether international commodity prices were primarily stock, flow, or mixed stock-flow determined. He noted that the stock approach assumes that the price level is determined by the level of inventory, while the flow approach assumes that prices are determined by excess supply (or demand) as measured by the difference between production and consumption.

Hwa formulated the following general system of equations to define, for a storable commodity, the supply of, and the demand for, stock:

$$C_t = a P_t + bX_t + u_t \qquad a < o \qquad (4\text{-}9)$$

$$Q_t = cP_t + dY_t + v_t \qquad c > o \qquad (4\text{-}10)$$

$$H^d_t = f(P^e_{t+1} - P_t) + gZ_t + w_t \qquad e > o \qquad (4\text{-}11)$$

$$H_t = H_{t-1} + Q_t - C_t \qquad (4\text{-}12)$$

where C_t is the rate of consumption during period t; Q_t is the rate of production during period t; H^d_t is the demand for stock at the end of period t; H_t is the actual stock at the end of period t; P_t is the auction market commodity price during period t; P^e_{t+1} is the price level expected to prevail at time t+1; X_t,Y_t and Z_t are exogenous explanatory variables (which differ depending on the commodity being examined); and u_t, v_t and w_t are disturbance terms. 17/

Hwa augmented this system of equations: (i) by postulating a partial adjustment process for price changes such that

$$P_t - P_{t-1} = r\,(P^d_t - P_{t-1}) \qquad o \leq r \leq 1 \qquad (4\text{-}13)$$

where P^d_t is the price level that balances the short-run supply and demand for stock; and (ii) by adopting the rational expectations hypothesis of John Muth (1961) 18/ to explain price expectations and therefore obtain an expression for P^e_{t+1}. With this hypothesis, he noted that the predicted price for period t+1 is equal to the expected price predicted by the model, conditional on all information available at the time the prediction is made. In other words, the information set

could include only the values of those variables in equations 4-9 to 4-12 that are predetermined at time t.

Using the above equations, Hwa was able to derive an expression for price (P_t) in the international copper market which he then tested, using both ordinary least squares and instrumental variables techniques, on annual data for the period 1955 to 1975. For P_t, he used the LME price, which is highly correlated with the Comex price we will be using in our analysis. His results led him to conclude that: (i) the international markets for the commodities he tested, including copper, are consistent with the mode of a competitive market; (ii) the changes in primary commodity prices are determined by stock disequilibria; (iii) price expectations apparently had differing degrees of influence on commodity prices after 1973 than before, suggesting that the underlying forces governing price expectations may be unstable at times; and (iv) one year's time may not be sufficient for prices in the metal markets to adjust to and reach a short-run equilibrium.19/

Footnotes

Chapter IV

1/ Charles River Associates, Inc., Economic Analysis of the Copper Industry, General Services Administration, Washington, D.C. March 1970, pages 256-325.

2/ Ibid., page 294.

3/ Ibid., page 305.

4/ For a description of the Hildreth-Lu procedure, the interested reader is referred to Henry J. Cassidy, Using Econometrics: a beginner's guide, Reston Publishing Company, Inc., Reston, Virginia, 1981, page 179.

5/ Charles River Associates, Inc., op.cit., pages 257-258.

6/ Franklin M. Fisher, Paul H. Cootner, Martin Neil Baily, "An Econometric Model of the World Copper Industry", Bell Journal of Economics and Management Science, Vol. 3, No. 2 (Autumn 1972), page 568.

7/ Fisher, Cootner and Baily, op.cit., page 570.

8/ Ibid., page 571.

9/ Ibid., page 573.

10/ Ibid., page 574.

11/ Ibid., page 576.

12/ Ibid., page 596.

13/ B.T. McCallum, "Competitive Price Adjustments: An Empirical Study", American Economic Review, Vol. 64 (March 1974), page 56.

14/ For a brief discussion of the Supply of Storage theory, refer to Chapter V, page 55.

15/ McCallum, op.cit., page 64.

16/ E.C. Hwa, "Price Determination in Several International Primary Commodity Markets: A Structural Analysis", International Monetary Fund Staff Papers, Vol. 26, No. 1 (March 1979), page 157.

17/ Ibid., page 161.

18/ John F. Muth, "Rational Expectations and the Theory of Price Movements", Econometrica, Vol. 29, No. 3 (July 1961), page 315.

19/ Hwa, op.cit., page 185.

Chapter V

MODEL FORMULATION

In this chapter, we will formulate an econometric disequilibrium model to enable us to test the hypothesis made in Chapter I that the major producers of refined copper in the United States have been trading copper at or near auction prices, instead of at producer prices. In our attempt to demonstrate support for our hypothesis, we will take advantage of the alleged change in producer pricing policies from about mid-1978 onwards. As shown in Chapter II, there were often significant differences between auction prices and the U.S. producer price prior to mid-1978, but after that time auction prices and the U.S. producer price have followed each other closely. We will therefore formulate the equation in our econometric model to explain the observed behavior of the producers after mid-1978 assuming that they traded refined copper at the auction prices established on the Comex. We will then estimate the model using monthly average data separately for the earlier subperiod from January 1975 to June 1978, for the later subperiod from July 1978 to December 1981, and also for the full period from January 1975 to December 1981. Doing this will enable us to use the Chow test and/or a dummy variable approach to test for equality between the sets of coefficients of our equations for the two subperiods.1/2/ If, as we expect, the sets of coefficients are found to

be equivalent, then we will have some evidence that the producers traded copper at our near auction prices prior to mid-1978 as well as after, and our hypothesis will be supported.

We will formulate the model: (i) to describe the producers' demand for inventories of refined copper (which we will term "inventory demand") in the basic forms, such as electrolytic wirebars and cathodes, that are produced by refineries; (ii) the demand of the semi-fabricating markets for refined copper ("demand for deliveries"); (iii) the supply of refined copper from primary sources ("primary supply"); (iv) the supply of refined copper from secondary sources ("secondary supply"); and (v) the demand of the U.S. market for net imports ("demand for net imports"). We should note that the inventory demand equation will enable the model to distinguish between the demand for inventories (or, as will be shown later, the demand for changes in inventories) and the actual level of inventories, just as supply is distinguished from production and demand from consumption. The model will also be formulated to explain monthly movements in the historical data. We will formulate a disequilibrium model since in the real world the copper market may be unable to adjust to a new equilibrium within month-long intervals. Technological constraints, institutional inertia, and contractural obligations, for example, are factors which could hinder a complete adjustment. The model will assume stability in the underlying supply and demand forces, including constancy of technology

over the period being tested from 1975 to 1981. Given the shortness of this time frame, we consider this assumption to be acceptable, particularly since we are asserting that the behavior of the producers has not changed materially at least since 1975.

The Modelling Method

To formulate our disequilibrium model, we will draw heavily upon the theoretical work of Ray C. Fair and Dwight M. Jaffee (1972) who helped to pioneer the development of the "short-side" methods of estimating supply and demand schedules in disequilibrium markets, and upon the work of Roger J. Bowden (1978) who helped to elaborate upon those methods.3/4/ In the "short-side" methods, quantities actually transacted are postulated to be determined by the short-side of the market as shown in Figure 5-1. The locus ABC is termed the "short-side" of the market, and corresponds to the range of possible prices. If there is excess supply, say at price P_1, then the quantity transacted will be Q_1. Similarly, if there is excess demand at price P_2, then the quantity transacted will also be Q_1. The basic idea behind the model is that consumers cannot be sold more than they want, and that no more can be sold than is supplied.5/ If there is an imbalance of supply and demand, the quantities actually transacted are determined as the minimum of the quantity demanded and the quantity supplied.6/

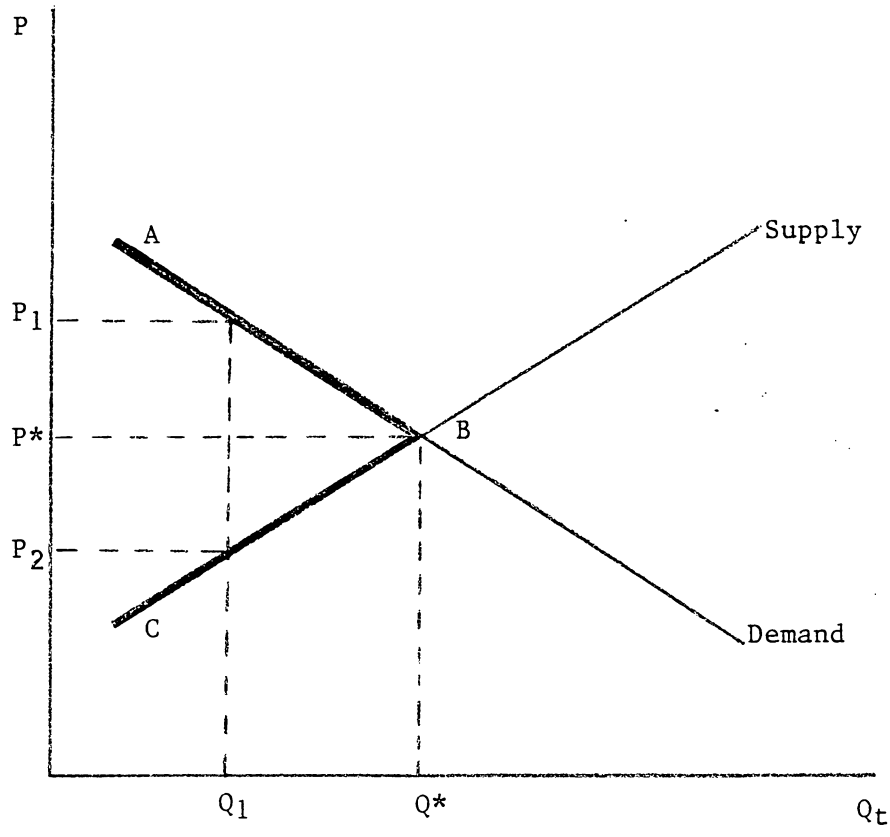


Figure 5.1. The Short-Side of the Market

A general simultaneous system of equations based on the "short-side" method can take the form:7/

$$D_t = a_1 P_t + b_1 X_{1t} + U_{1t} \qquad (5\text{-}1)$$

$$S_t = a_2 P_t + b_2 X_{2t} + U_{2t} \qquad (5\text{-}2)$$

$$Q_t = \min (D_t, S_t) \qquad (5\text{-}3)$$

$$P_t = uP_{t-1} + (1-u) P_t^* + U_{3t} \quad 0 \leq u \leq 1 \qquad (5\text{-}4)$$

$$D(P_t^*) = S(P_t^*) \qquad (5\text{-}5)$$

where D_t is demand in period t; S_t is supply in period t; P_t is the actual price in period t; X_{1t} and X_{2t} are exogenous, explanatory variables in period t; Q_t is the transacted quantity in period t; P_t^* is an imputed equilibrium or market-clearing price in period t; U_{1t}, U_{2t} and U_{3t} are disturbance terms in period t; a_1, b_1, a_2, b_2 are coefficients; and u is a "friction" parameter.

If equations 5-4 and 5-5 are combined, the imputed market-clearing price (P_t^*) is defined by

$$P_t^* = \frac{1}{a_1 - a_2} (b_2 X_{2t} - b_1 X_{1t}) + \frac{1}{a_1 - a_2} (U_{2t} - U_{1t}) \qquad (5\text{-}6)$$

if it is assumed that the disturbance term $U_{3t} = 0$. When $U_{3t} = 0$, market-clearing is considered to be error-free.

The quantities D_t and S_t defined by equations 5-1 and 5-2 are not directly observable, but their minimum or "short-side", equation 5-3, defines the observable transacted quantity Q_t. Equation 5-4 specified an adjustment process in terms of a partial adjustment to an imputed moving equilibrium (termed the competitive PAMEQ specification), and it allows a time series to be decomposed into disequilibrium fluctuations superimposed on longer-run equilibrium movements. Bowden has noted that the PAMEQ specification, if desired, could also be expressed in terms of a more general distributed lag formulation.8/ We will see that the PAMEQ specification allows the model to discrimate between periods of excess supply and excess demand to determine whether an observed data point should lie on the demand curve or on the supply curve.

Bowden has shown that equations 5-1 to 5-4 can be separated into two systems of equations corresponding to excess supply and excess demand.9/ For excess supply, $P_t > P_t^*$ and the equations become:

$$Q_t = a_1P_t + b_1X_{1t} + U_{1t} \text{ (Demand)} \tag{5-7}$$

$$Q_t = a_2P_t + B_2X_{2t} - (a_2-a_1)(P_t-P_t^*) + U_{2t} \text{ (Supply)} \tag{5-8}$$

$$P_t = uP_{t-1} + (1-u)P_t^* + U_{3t} \tag{5-9}$$

For excess demand, $P_t < P_t^*$ and the equations become

$$Q_t = a_1P_t + b_1X_{1t} + (a_2-a_1)(P_t-P_t^*) + U_{1t} \text{ (Demand)} \tag{5-10}$$

$$Q_t = a_2P_t + b_2X_{2t} + U_{2t} \quad \text{(Supply)} \tag{5-11}$$

$$P_t = uP_{t-1} + (1-u)P_t^* + U_{3t} \tag{5-12}$$

When market-clearing is considered to be error-free ($U_{3t}=0$), the demand and supply equations can be combined with the PAMEQ specification, which can be rewritten as

$$(P_t-P_t^*) = - \frac{u}{1-u} (P_t-P_{t-1}) \tag{5-13}$$

to produce the following summary equations:

$$Q_t = a_1P_t + b_1X_{1t} - r\,\Delta P_t + U_{1t} \quad \text{(Demand)} \tag{5-14}$$

where $\Delta P_t = P_t - P_{t-1} = \Delta P_t$ if $\Delta P_t > 0$

$= 0$ otherwise

and $r = \frac{u(a_2-a_1)}{1-u}$; and

$$Q_t = a_2 P_t + b_2 X_{2t} + r\,\Delta P_t + U_{2t} \quad \text{(Supply)} \qquad (5\text{-}15)$$

where $\Delta P_t = 0$ if $\Delta P_t > 0$

$= \Delta P_t$ otherwise.

The discriminant between excess demand and excess supply therefore becomes the change in price ($\Delta P_t = P_t - P_{t-1}$). If $\Delta P_t < 0$, then $P_t > P_t^*$ and excess supply is assumed by the model. The quantity Q_t is therefore assumed to lie on the demand curve. A converse situation arises if $\Delta P_t < 0$. If $\Delta P_t = 0$, then $P_t = P_t^*$ and the system of equations will reduce to those of the standard equilibrium model.

Specification of the Model

The Inventory Demand Equation

We will postulate that the producers will demand inventories in accordance with:

$$D^i_t = a_0 + a_1(P^e_{t+1} - P_t) + a_2 Q^i_{t-1} + a_3 Y_t + U_{1t} \qquad (5\text{-}16)$$

where D^i_t is the producers' demand for inventories at the end of period t; P^e_{t+1} is the expected auction price in the United States in period t+1; P_t is the U.S. auction price in period t; Q^i_{t-1} is the level of inventories held by producers at the end of period t-1; and Y_t is a variable representing the level of activity in the semi-fabricating and end-use markets in the United States. a_o is a constant, a_1 to a_3 are coefficients, and U_{1t} is a disturbance term.

The relationship $a_1(P^e_{t+1} - P_t)$ was postulated by John Muth.10/ He demonstrated that such a relationship could be used as a first approximation for the inventory position at time t when: (i) price changes were small; (ii) prices were normally distributed; and (iii) the square of the expected price change was small relative to the variance. He derived this relationship assuming the objective to maximize expected utility from speculative profits. Support for this relationship can also be found in the literature on the supply of storage theory originally proposed by Holbrook Working (1949) and then expanded upon by Michael Brennan (1958).11/12/ Brennan derived a similar relationship by assuming that, in a competitive industry in an uncertain world, a firm seeking to maximize profits will hold an amount of inventory such that the net marginal cost of storage per unit of time equals the expected change in price per unit of time.

The level of inventories (Q^i_{t-1}) at the end of period t-1 has been included in the equation since the producers' could be expected to increase inventories in period t willingly, or alternatively allow them to decrease, only if they considered the level at the end of period t-1 to be inappropriate to meet the transaction requirements caused by imperfect matching of production and consumption, and the precautionary requirements necessary to provide protection against uncertainties such as labor unrest. An economic activity variable (Y_t) has also been included in equation 5-16 since the producers' transaction and precautionary needs can be expected to be influenced by the level of economic activity in the semi-fabricating and end-use markets. More ideally, however, we should incorporate a variable to reflect expected economic activity. To provide an approximation of this, we will also estimate equation 5-16 in Chapter VI with lagged values of Y_t included. An alternative to Y_t is the deliveries variable (X^d_t), but we considered that economic activity information would be a more useful indicator to the producers in determining desired inventory levels. Moreover, we considered also that using X^d_t in the equation could introduce possible definitional problems that might lead to spurious correlations.

We should note that including Q^i_{t-1} in the equation will produce a distributed lag effect of P_t and ΔP_t and of the other explanatory variables, all having the same distribution, on inventory demand. In some respects, therefore, this formulation will be similar

to that used by Fisher et al. (Chapter IV). In Chapter VI, we will test equation 5-16 in a more general distributed lag formulation. Doing so will accord with our earlier observation that the PAMEQ specification can be generalized and expressed in terms of a distributed lag formulation.13/

We should note here also that, in the inventory demand equation, we are attempting to explain how inventory levels (or stocks), and not changes (or flows) in inventories, are determined. The distinction, however, is not considered to be of serious importance since, as will be shown later, we could formulate an equivalent flow equation by subtracting Q^i_{t-1} from both sides of the equation. (We will also see later that, after applying the "short-side" modelling method just outlined, the dependent variable will become Q^i_t). The coefficient of Q^i_{t-1} would then differ by 1.0.

The Primary Supply Equation

We will postulate that the major copper producers will supply refined copper from primary sources in accordance with:

$$SP_t = c_o + c_1 P_t + c_2 X P_{t-1} + c_3 X\, {}^{s}_{t} + c_4 X\, {}^{c}_{t} + U_{3t} \qquad (5\text{-}17)$$

where SP_t is the producers willingness to produce primary refined copper

in period t, X^{P}_{t-1} is the level of production of primary refined copper in period t-1, X^{S}_{t} is the producers' production of refined copper from secondary sources in period t, and X^{C}_{t} is a factor related to the unit cost of production of refined copper in period t. The other variables have been described previously. c_0 is a constant, c_1 to c_4 are coefficients, and U_{3t} is a disturbance term.

The producers' current level of production of refined copper, both from primary sources (X^{P}_{t}) and from secondary sources (X^{S}_{t}), could be expected to impose constraints on their willingness to supply refined copper for inventories at the end of period t. Production from primary sources could be particularly constraining, since adjusting the level of primary production might well imply the need to adjust production and/or the level of stockpiling at smelters and mines. Adjusting production from secondary sources may be less critical, since scrap purchases could either be curtailed or be increased more readily than could production at smelters and mines. The level of production (X^{P}) in period t-1 can therefore be expected to influence S^{P}_{t}. The inclusion of X^{P}_{t-1}, however, provides for a distributed lag effect of the other explanatory variables, all having the same distribution, on primary supply. In Chapter VI, a more general distributed lag formulation will also be tested. In addition, the producers' willingness to produce refined copper from primary sources can be expected to be influenced by the current level of their secondary production, which may or may not be

constraining on the level of primary production depending upon available plant capacity. The variable (X^c_t) has also been included in equation 5-17 since the unit cost of production relative to the auction price will be a major determinant of the profitability of producing refined copper.

The Secondary Supply Equation

We will postulate that the copper producers will supply refined copper from secondary sources in accordance with:

$$S^s_t = d_o + d_1 P_t + d_2 X^s_{t-1} + d_3 X^p_t + d_4 P^s_t + U_{4t} \qquad (5\text{-}18)$$

where S^s_t is the producers' willingness to produce secondary refined copper in period t, X^s_{t-1} is the level of production of secondary refined copper in period t-1, and P^s_t is the price of scrap in period t. d_o is a constant, d_1 to d_4 are coefficients, and U_{4t} is a disturbance term. This equation is similar to that for primary supply, except that the roles of X^s and X^p have been reversed and X^c_t has been replaced by P^s_t, since the latter is considered to be a more appropriate indicator of the cost of secondary production.

Demand for Deliveries Equation

The demand for deliveries is a derived demand since refined copper is a factor of production in the semi-fabricating industries. To obtain an appropriate expression for the overall market demand for refined copper, therefore, we must look first at the demand for refined copper at the level of the individual firm. We have hypothesized that the producers of refined copper trade at auction prices and behave as "price takers," and therefore we will assume for our analysis that the semi-fabricators face a refined copper market characterized by competitive behavior. In addition, we will assume, on the basis of our review of the U.S. copper market and industry in Chapter III, that the semi-fabricating industries are also characterized by competitive behavior. Under these circumstances, if refined copper is the firm's only variable factor of production, the firm will increase its use of refined copper as long as it contributes to profitability. In particular, the firm will employ refined copper until the value of the marginal product of refined copper (VMP_c), where $VMP_c=MP_c x P_s$ and P_s is the price of the semi-fabricated product made from copper, is greater than the price of copper (P_c). The demand schedule for refined copper therefore becomes the declining part of the VMP_c schedule.

Perhaps more correctly, however, we should assume that refined copper is only one of several variable factors entering the production

processes of the semi-fabricators. Other factors, for example, could include labor and substitute materials such as aluminum. In these circumstances, the firm's demand schedule for refined copper is not the VMP_c schedule but the schedule traced by shifts in the VMP_c schedule when external influences cause the price of copper (P_c), and/or the price of subsitute materials, to change. The changes will lead the firm to alter its degrees of usage of the various factors of production as it attempts to reestablish a least-cost combination of inputs and maximize its profitability. In addition, when we aggregate the demand schedules of the individual firms to derive the market demand for refined copper, we must also consider external influences on the semi-fabricators that can lead to changes in the prices (P_s) of semi-fabricated products, since such changes will in turn cause changes in VMP_c. One such influence could be the initial change in P_c, and another could result from shifts in the demand schedules for semi-fabricated products. Still another could be changes in technology which could alter the marginal productivities of the various factor inputs. As noted earlier in this chapter, however, we have assumed constancy of technology.

We will therefore postulate that semi-fabricators will demand deliveries of refined copper in accordance with:

$$D^d{}_t = e_o + e_1 P_t + e_2 P^{al}{}_t + e_3 Y_t + U_{5t} \qquad (5\text{-}19)$$

where D^d_t is the demand for deliveries in period t, P^{al}_t is the price of aluminum in period t, and Y_t is a variable representing the level of economic activity in the semi-fabricating and end-use markets. e_o is a constant, e_1 to e_3 are coefficients, and U_{5t} is a disturbance term.

Equation 5-19 is thought to provide a reasonable approximation of the theory of derived demand, but is limited particularly with respect to its ability to take external influences into account. The variable Y_t, for example, is being used to serve as an indicator of the demand for semi-fabricated products. We have included the aluminum price in the equation, since aluminum is possibly the most significant competitor to refined copper. In Chapter VI, we will also test for distributed lag effects of the explanatory variables on demand.

Demand for Net Imports Equation

We will postulate that consumers of refined copper in the United States will demand net imports (imports-exports) in accordance with:

$$D^m_t = f_o + f_1 (P_t - P^{lme}_t) + U_{6t} \qquad (5\text{-}20)$$

where D^m_t is the demand for net imports and P^{lme}_t is the auction price of refined copper on the London Metals Exchange (LME). f_o is a

constant, f_1 is a coefficient, and U_{6t} is a disturbance term.

We have postulated that the demand for net imports is explained primarily by the difference between the auction price of refined copper in the United States and that on the LME because it is this price difference which could provide consumers with a motive to import refined copper instead of purchasing it domestically. In Chapter VI we will also test for distributed lag effects of the explanatory variables on demand.

System of Equations for Estimation

Using the "short-side" modelling method outlined earlier in this chapter, we can now specify a general system of equations for estimation purposes. We will assume that market-clearing is error-free, since we have hypothesized that refined copper is being traded at prices established in auction markets where no significant barriers to price adjustment are present and information about prices is readily available. Out equations therefore become as follows:

Inventory Demand

$$Q_t = a_0 + a_1 (P^e_{t+1} - P_t) + a_2 X^d_t + a_3 Q^i_{t-1} - r_1 \Delta P_t + U_{1t} \qquad (5\text{-}21)$$

where $\Delta P_t = P_t - P_{t-1} = \Delta P_t$ if $\Delta P_t > 0$

$= 0$ otherwise.

r_1 is a coefficient.

Primary Supply

$$XP_t = c_o + c_1 P_t + c_2 X\ P_{t-1} + c_3 X\ ^{s}_{t} + c_4 X\ ^{c}_{t} + r_2\ \Delta P_t + U_{3t} \qquad (5\text{-}22)$$

where $\Delta P_t = 0$ if $\Delta P_t > 0$

$= \Delta P_t$ otherwise

Secondary Supply

$$X^{s}_{t} = d_o + d_1\ P_t + d_2 X\ ^{s}_{t-1} + d_3 X P_t + d_4 P^{s}_{t} + r_3\ \Delta P_t + U_{4t} \qquad (5\text{-}23)$$

where $\Delta P_t = 0$ if $\Delta P_t > 0$

$= \Delta P_t$ otherwise.

Demand for Deliveries

$$X^{d}_{t} = e_o + e_1\ P_t + e_2\ pal_t + e_3\ Y_t - r_4\ \Delta P_t + U_{5t} \qquad (5\text{-}24)$$

where $\Delta P_t = \Delta P_t$ if $\Delta P_t > 0$

$= 0$ otherwise.

Demand for Net Imports

$$X^m_t = f_o + f_1 (P_t - P^{lme}_t) - r_5 \Delta P_t + U_{6t} \qquad (5\text{-}25)$$

where $\Delta P_t = \Delta P_t$ if $\Delta P_t > 0$

$= 0$ otherwise.

Footnotes

Chapter V

1/ Chow, op.cit.

2/ Gujarati, op.cit.

3/ Fair and Jaffee, op.cit.

4/ Bowden, op.cit.

5/ Ibid., page 10.

6/ Ibid., page 155.

7/ Ibid., page 164.

8/ Ibid., page 76 and 82.

9/ Ibid., pages 164-166.

10/ Muth, op.cit.

11/ Holbrook Working, "The Theory of Price of Storage," American Economic Review, Vol. 39 (December 1949), page 1254.

12/ Michael J. Brennan, "The Supply of Storage," American Economic Review, Vol. 48 (March 1958), page 50.

13/ For a discussion of distributed lag formulations, the interested reader is referred to Potluri Rao and Roger Miller, Applied Econometrics, Wadsworth Publishing Company, Inc., Belmont, California, 1971, pages 160 to 179.

Chapter VI

ECONOMETRIC ESTIMATION

We will estimate the model specified by equations 5-21 to 5-25 using two alternative procedures. First, we will make the naive assumption that P_t, and therefore ΔP_t, are exogenous, and use ordinary least squares (OLS) to estimate each equation. Secondly, we will make the more plausible assumption that P_t and ΔP_t are endogenous, and use two stage least squares (TSLS) to provide a simultaneous estimate of each equation. Irrespective of our assumptions, however, the OLS estimates will provide a benchmark for comparison with the TSLS estimates. For the sample sizes we will be using (approximately 40 to 80), the TSLS estimator is expected to provide estimates of the coefficients with much lower bias than those provided by the OLS estimator, but on the other hand the OLS estimator is expected to provide estimates having lower variance. 1/

Descriptions of the Data

The descriptions, sources and computer nomenclature of the data we will employ are summarized in Table 6-1, and the data is tabulated in Appendix 1. Monthly data will be used for all variables, and we will use only data expressed in real terms. Accordingly, we will

Table 6-1

Data Sources, Descriptions and Computer Nomenclature

Symbol	Computer Term 1/	Description	Source
-	EXPRTS	U.S. Exports of refined copper during each month (thousands of short-tons)	U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, various issues
-	IMPRTS	U.S. imports of refined copper during each month (thousands of short-tons)	Survey of Current Business
XP_t	NETIMP	Net imports of refined copper during each month (thousands of short-tons)	Survey of Current Business
Q^i_t	INVREF	Refiner's inventories of refined copper at the end of each month (thousands of short-tons)	American Metal Market, Metal Statistics 1979, 1980, 1981, and 1982.
P_t	DPRCOM	Deflated Comex first (spot) price, electrolytic copper (US cents per pound)	McGraw-Hill Publishing Company, New York, Metals Week, various issues
P^e_{t+1}	DPRTWO	Deflated Comex second (futures) price, electrolytic copper (for delivery in about one year) (US cents per pound)	Metals Week
-	DPRTHR	Deflated Comex third (futures) price, electrolytic copper (for delivery in about one year) (US cents per pound)	Metals Week
-	DPRODP	Deflated U.S. producer price, electrolytic copper, wirebars f.o.b. refinery (US cents per pound)	Metals Week
-	DSCRPR	Deflated refiners' buying price for No. 2 copper scrap at New York (US cents per pound)	Metal Statistics
XP_t	PRIMPD	Refined copper production from primary sources during each month (thousands of short-tons).	Survey of Current Business
X^s_t	SECPD	Refined copper production from secondary sources during each month (thousands of short-tons)	Survey of Current Business
X^c_t	DMPRC	Deflated average hourly earnings during each month, production-workers, primary non-ferrous metals (US dollars)	U.S. Department of Labor, Employment and Earnings, 1909-1978, Bulletin 1312-11 (SIC 333) and Supplement to Employment and Earnings, Revised Establishment Data, September 1982
Y_t	INDMATPR	Federal Reserve Board's monthly index of industrial production (quantity output of materials)(not seasonally adjusted) 3/	Survey of Current Business
p^{lme}_t	DPRLME	Deflated LME cash price, electrolytic copper wirebars (US cents per pound)	Metal Bulletin, London, and UNCTAD, Geneva, Monthly Commodity Price Bulletin
p^{al}_t	DPRAL	Deflated Canadian aluminum price, aluminum ingots of 99.5% minimum purity, delivered United Kingdom (US cents per pound)	The Financial Times, London, and UNCTAD, Geneva, Monthly Commodity Price Bulletin
X^d_t	DELIV	Domestic deliveries of refined copper in the United States from all sources (thousands of short-tons)	Metal Statistics
-	PRIDF	Producer price index for finished goods (1967=1.00)	Survey of Current Business
$P^e_{t+1}-P_t$	DPRCHTWO	DPRTWO-DPRCOM	
ΔP_t	DCHPRN	DPRCOM-DPRCOM(-1), for use in demand equations, where $\Delta P_t = \Delta P_t$ if $\Delta P_t > 0$; otherwise $\Delta P_t = 0$.	
ΔP_t	DCHPRSN	DPRCOM-DPRCOM(-1), for use in supply equations, where $\Delta P_t = 0$ if $\Delta P_t > 0$; otherwise $\Delta P_t = \Delta P_t$.	
D_6	LABUNR	Dummy variable to take periods of labor unrest into account	
D_{s1}, D_{s2}, D_{s3}	SONE, STWO, STHR	Seasonal dummy variables (quarterly periods)	
D_1	DM	$D_1=1$ if the observation lies in the first subperiod from December 1975 to June 1978, and $D_1=0$ if the observation lies in the second subperiod from July 1978 to December 1981.	

1/ The addition of the letter "D" as a prefix to the computer term indicates that the data have been deflated to reflect purchasing power of the U.S. dollar by multiplication with PRIDF.

2/ All prices are monthly averages.

3/ Includes: (i) durable goods materials, such as durable consumer parts and equipment parts, (ii) non-durable goods materials used in textile, paper and chemical industries, and (iii) energy materials.

use the Producer Price Index for Finished Goods, published by the U.S. Department of Labor, Bureau of Labor Statistics, to convert data expressed in nominal money terms to real terms. The U.S. Department of Labor publishes this index to reflect the purchasing power of the U.S. dollar at the primary market level. Brief descriptions of the data we will use for the key variables are given below.

Auction Price (P_t)

We will use the Comex first, or spot price, for electrolytic copper in the form of cathodes (US cents per pound) as the auction price in the demand and supply equations. We have selected the Comex price instead of the LME price since the Comex, although perhaps less important to world trade in copper than the LME, is considered to provide a better reflection of events in the U.S. market for refined copper. The selection, however, should not be critical to the results of our analysis since, as discussed in Chapter II, the Comex and LME prices are usually close together and highly correlated.

Expected Auction Price (P^e_{t+1})

The Comex second, or futures price, for electrolytic copper in the form of cathodes (US cents per pound) specified for delivery within two months of the date of contract, will be used as the expected auction

price in period t+1. Hwa (Chapter IV) suggested that the futures price may be inappropriate to use as the expected price primarily because of a finding by Labys and Granger (1970) that the futures price does not seem to lead the spot price, and therefore may not be a good predictor of the expected spot price 2/3/. We consider, however, that trading on the Comex is sufficiently free of disturbances and hindrances to enable the futures prices determined on the exchange to adequately reflect traders' expectations.

Scrap Price (P^s_t)

We will use the refiners' buying price for No. 2 copper scrap at New York (U.S. cents per pound), published by "Metals Week," as the scrap price in the secondary supply equation. No. 2 scrap is one of the most common categories of scrap, and comprises mixed heavy and light copper which includes unalloyed copper scrap that is relatively free of contaminants and contains between 92 and 96 percent copper.

Deliveries (X^d_t)

Data on the level of deliveries from the major producers to consumers could not be found; instead, we will use data on domestic deliveries of refined copper to semi-fabricators in the United States (thousands of short-tons) from all sources, as reported by the American

Bureau of Metal Statistics. The deliveries include copper withdrawn from and delivered to government stocks, and also imports of refined copper. Use of this data is not expected to detract from the merits of the model for two reasons. First, deliveries from the producers constitute the bulk of the total, and second, the producers' demand for inventories can be assumed to be directly related to the overall level of activity in the market.

Inventories (Q^i_t)

We will use refiners' inventories of refined copper at the end of each month (thousands of short-tons), as reported by the American Metal Market, to represent inventories held by major producers. This data includes inventories held by small refiners in addition to those held by the major producers, but this should not detract from the usefulness of our model particularly since we are postulating that the producers have not used inventory policies to administer market prices.

Primary Production (XP_t) and Secondary Production (X^s_t)

The model will use data on refined copper production from primary sources (thousands of short-tons) and data on refined copper production from secondary sources (thousands of short-tons), both published by the U.S. Department of Commerce.

Production Cost Factor (X^c_t)

Good data on the cost of producing refined copper could not be found. We therefore employed data published by the U.S. Department of Labor on the average hourly earnings (U.S. dollars) of production workers in primary non-ferrous metal industries, which we considered to be one of the best available indicators of production costs.

Aluminum Price (P^{al}_t)

The aluminum price in the United States is, like the producer price of copper, an administered price. Since the producers' list prices are often thought to be widely discounted, we considered a better indicator of the actual aluminum price in the United States to be the Canadian aluminum price (U.S. cents per pound) for aluminum ingots of at least 99.5 percent purity, delivered to the United Kingdom. This price takes into account the additional costs of delivery to the United Kingdom, but these costs are relatively constant. The underlying dynamics of this price could therefore be considered to be representative of North American aluminum prices if one assumes that the aluminum market is fairly competitive in nature.

Net Imports (X^m_t)

Data on U.S. imports and exports of refined copper (thousands of short-tons) are published by the U.S. Department of Commerce. We derived our data for net imports by simply taking the difference between imports and exports.

Economic Activity (Y_t)

As an indicator of economic activity in the semi-fabricating and end-use markets, we used the Federal Reserve Board's monthly index of industrial production of materials (not adjusted for seasonality). This index takes into account activity in the markets for: (i) durable goods materials, such as durable consumer parts and equipment parts; (ii) non-durable goods materials used in textile, paper and chemical industries; and (iii) energy materials. The index was considered appropriate since refined copper is an important input into the manufacture of both durable goods and energy materials in particular.

Estimation Results

We estimated each of the equations 5-21 to 5-25, in linear forms, for the period from January 1975 to December 1981 and for the two subperiods from January 1975 to June 1978 and from July 1978 to December

1981. We included quarterly seasonal dummies in our equations, since our data have not been adjusted for seasonality, and also a dummy variable to take account of periods of labor unrest. The copper producers experienced significant labor strife on two occasions between January 1975 and December 1981, covering approximately the months from July to September of 1977, and from July to November of 1980.

We first applied the Chow test to our OLS results for each equation. In summary, this test requires that we calculate the F-statistic

$$F = \frac{(RSS_1 - RSS_4)/k}{(RSS_2 + RSS_3)/(N_1 + N_2 - 2k)}$$

with degrees of freedom k and N_1+N_2-2k, where:

(i) RSS_1 is the residual sum of squares of the regression equation for the full period having N_1+N_2 observations and k parameters;

(ii) RSS_2 is the residual sum of squares of the equation for the first subperiod having N_1 observations and k parameters;

(iii) RSS_3 is the residual sum of squares of the equation for the second subperiod having N_2 observations and k parameters; and

(iv) $RSS_4 = RSS_2 + RSS_3$. 4/ 5/

If F is greater than F_c, where F_c is the F statistic corresponding to significance level c, we can reject the hypothesis, at that significance level, that the regression coefficients for the two subperiods are equivalent. If F is less than F_c, then we should not reject the hypothesis on the basis of the Chow test. To confirm the Chow test if it indicates that we should not reject the hypothesis, or alternatively to determine whether the differences between the equations lie with the intercept terms, the slope coefficients, or both, we will employ a dummy variable technique described by Gujarati using both OLS and TSLS.6/

The dummy variable approach requires that we create a dummy variable (D) where: (i) D = 1 if the observation lies in the first subperiod of N_1 observations; and (ii) D = 0 if the observation lies in the second subperiod of N_2 observations. The dummy variable is then introduced into the regression equation for the full period of $N_1 + N_2$ observations in both additive and multiplicative forms. For example, in equation 5-21 for inventory demand, the new equation would become:

$$Q_t = a_o + a_1 D + a_2 (P^e_{t+1} - P_t) + a_3 D(P^e_{t+1} - P_t)$$

$$+ a_4 X d_t + a_5 D X d_t + a_6 Q^i_{t-1} + a_7 D Q^i_{t-1}$$

$$- r_1 \Delta P_t + U_{1t} \qquad (6\text{-}1)$$

In equation 6-1, the coefficient a_1 is termed a differential intercept coefficient and the coefficients a_3, a_5, and a_7 are termed differential slope coefficients. If a_1 is not statistically significant, then a_o gives an estimate of the common intercept for both subperiods. If, on the other hand, a_1 is statistically significant, then the intercept value of the first subperiod is $a_1 + a_o$ and the intercept value of the second subperiod is a_o. Similarly, if a_3, a_5, and a_7 are not statistically significant, then a_2, a_4 and a_6 give estimates of the common slope coefficients. If, however, a_3 is significant, for example, then the coefficient of $(P^e_{t+1}-P_t)$ would be $a_2 + a_3$ for the first subperiod and a_2 for the second subperiod.

Inventory Demand

In theory, equation 5-21 for inventory demand should have the same coefficient for P^e_{t+1} as for P_t. We estimated the equation after taking the difference between P^e_{t+1} and P_t, thereby constraining the coefficients to be equal, but we also estimated the equation with P^e_{t+1} and P_t included separately. The results of this second estimation provided reasonably close coefficients for the two variables, particularly for the second subperiod from July 1978 to December 1981.

In accordance with our hypthesis, we first estimated equation 5-21 for the second subperiod using OLS. We found that when we added Q^i_{t-2} to the equation as an explanatory variable, the coefficient of Q^i_{t-2} had a highly significant t-statistic of -2.19. We therefore decided to leave Q^i_{t-2} in the equation, recognizing that doing so would provide for a more complex distributed lag effect than was already present with Q^i_{t-1} in the equation. We also lagged the explanatory variable Y_t twice to enable adaptive expectations with respect to economic activity to be reflected in the equation, and also to help prevent Y_t from being constrained to have the same distributed lag effect on the dependent variable as that of P_t and ΔP_t.7/ In addition, we found that the Rho (diagnostic) for this equation was -0.141, implying the possible existence of first-order autocorrelation that may also be impure. The computer program did not calculate an H-statistic for this regression, nor did it calculate one for the regressions for the first subperiod and the full period. Nevertheless, we suspected that, if there was impure autocorrelation, it could be the result of either a missing relevant variable or else an incorrect functional form. We thought it more likely, however, that in this case the cause might be a missing relevant variable given the general simplicity of our equation and the apparent correctness of the signs.

We therefore decided to reestimate the equation using OLS with a Cochrane-Orcutt iterative correction procedure for auto-

correlation, in which the final OLS regression is carried out on the rho-transformed variables.8/ The Cochrane-Orcutt procedure gives biased but inconsistent estimates in distributed lag models, but is expected to be helpful in reducing the bias should there be a missing relevant variable. The procedure is also helpful in increasing precision if pure autocorrelation is present -- an important factor in terms of our objective to determine whether or not there is equivalence between the two subperiods. Another factor in our decision to use the Cochrane-Orcutt procedure was our desire for consistency in the estimation of all the equations in the model. It will be seen later in this Chapter that the use of the Cochrane-Orcutt procedure was strongly warranted in the estimation of the other equations. In reestimating equation 5-21 using the Cochrane-Orcutt procedure we found that the residual sum of squares fell from 5,203 to 1,200 and the F-statistic rose from 113.6 to 6,538. The $\bar{R}^2$ statistic also increased from 0.968 to almost 1.00.

Our regression results using the Cochrane-Orcutt procedure, for the full period and for the two subperiods, were as follows:

(i) January 1975 to December 1981:

$$Q^i_t = \underset{\substack{(108.6)\\ 2.8}}{300.86} + \underset{\substack{(8.1)\\ 1.4}}{10.89}(P^e_{t+1}-P_t) + \underset{\substack{(0.11)\\ 10.9}}{1.23}\, Q^i_{t-1}$$

$$
\begin{array}{llll}
-0.40\ Q^{i}_{t-2} & -1.46\ Y_t + 0.06\ Y_{t-1} & -0.21\ Y_{t-2} & \\
(0.11) & (0.56) \quad (0.72) & (0.57) & \\
-3.8 & -2.6 \quad 0.08 & -0.4 & \\
 & & & \\
-0.62\ \Delta P_t & -12.92\ D_{s1} & -8.24\ D_{s2} & \\
(1.3) & (5.3) & (4.8) & \\
-0.5 & -2.4 & -1.7 & \\
 & & & \\
-15.19\ D_{s3} & -16.03\ D_e & & (6\text{-}2) \\
(4.6) & (7.6) & & \\
-3.3 & -2.1 & &
\end{array}
$$

Number of Observations (N)	= 79
Residual Sum of Squares (RSS)	= 19,270
F (11, 67)	= 67.3
Rho	= 0.027
Standard Error of the Estimate (SEE)	= 17.0
Unadjusted R^2 (R^2)	= 0.92
Adjusted R^2 ($\bar{R}^2$)	= 0.92

The statistic in brackets beneath each coefficient in the estimated standard error of the coefficient. The other is the t-statistic for the coefficient.

(ii) January 1975 to June 1978:

$$
\begin{array}{llll}
Q^{i}_t = & 26.50 + & 0.96(P^{e}_{t+1}-P_t) + & 1.77\ Q^{i}_{t-1} \\
 & (13.7) \quad & (12.8) \quad & (0.09) \\
 & -1.9 \quad & 0.07 \quad & 19.6
\end{array}
$$

$$- 0.87\ Q^{i}_{t-2} + 1.94\ Y_t - 3.15\ Y_{t-1} + 1.83\ Y_{t-2}$$
$$(0.10) \qquad (1.0) \qquad (2.1) \qquad (1.2)$$
$$-8.7 \qquad 1.9 \qquad -1.5 \qquad 1.5$$

$$+ 1.00\ \Delta P_t - 25.98\ D_{s1} - 10.90\ D_{s2}$$
$$(1.4) \qquad (5.7) \qquad (3.0)$$
$$0.7 \qquad -4.5 \qquad -3.7$$

$$- 19.34\ D_{s3} + 3.48\ D_e \qquad (6\text{-}3)$$
$$(5.2) \qquad (5.0)$$
$$3.7 \qquad 0.7$$

N = 37 SEE = 15.3
RSS = 5,863 R^2 = 0.999
F (11,25) = 1,693 $\bar{R}^2$ = 0.998
Rho = -0.054

(iii) July 1978 to December 1981:

$$Q^{i}_t = 259.63 + 10.33\ (P^{e}_{t+1} - P_t) + 1.71\ Q^{i}_{t-1}$$
$$(87.2) \qquad (4.5) \qquad (0.06)$$
$$3.0 \qquad 2.3 \qquad 26.6$$

$$- 0.80\ Q^{i}_{t-2} - 1.34\ Y_t + 2.02\ Y_{t-1}$$
$$(0.05) \qquad (0.4) \qquad (0.8)$$
$$-14.6 \qquad -3.6 \qquad 2.7$$

$$- 2.21\ Y_{t-2} - 1.85\ \Delta P_t - 17.12\ D_{s1}$$
$$(0.7) \qquad (0.9) \qquad (3.8)$$
$$-3.3 \qquad -2.0 \qquad -4.5$$

$$+ 0.89\ D_{s2} - 8.48\ D_{s3} - 25.70\ D_e \qquad (6\text{-}4)$$

N = 37 SEE = 6.9
RSS = 1,200 $R^2 \cong 1.00$
F(11,25) = 6,538 $\bar{R}^2 \cong 1.00$
Rho = -0.110

The R^2 and $\bar{R}^2$ statistics for the three equations are all highly significant and indicate that the regression equation has a good fit and explains a large part of the variation of Q^i_t. The high R^2 values should be viewed cautiously, however, because we are using a stock variable instead of a flow variable as the dependent variable. A higher R^2 should be expected when the stock variable is used, since the total sum of squares should be higher in the stock form than in the flow form. This arises because of the difference in magnitude of the alternative dependent variables.9/ We find, for example, that reestimating equation 6-4 with the change in inventories ($Q^i_t - Q^i_{t-1}$) as the dependent variable instead of Q^i_t, reduced the R^2 and $\bar{R}^2$ statistics to 0.995 and 0.993, respectively, and reduced the F-statistic to 482.9. The only difference in the coefficients, however, was a reduction in the coefficient of Q^i_{t-1} by 1.0. The high R^2 and $\bar{R}^2$ statistics could suggest that spurious correlation may be present, but we note that this is unlikely because the equations do not appear to have definitional problems. Instead, the high values appear to result from the high statistical significance of the lagged dependent variables, and from the use of the Cochrane-Orcutt procedure. The F statistics for the three equations all exceed the critical values corresponding to the 99 percent level of confidence that the results properly represent the observed phenomena. We have not reported an H-statistic since we have applied a Cochrane-Orcutt correction to the estimates for each equation. When similar results are found for the

summary statistics for the equations discussed hereafter, we shall refer to them as being "statistically acceptable".

Using the residual sum of squares statistics generated by the regression equations, our F-statistic for the Chow test becomes:

$$F = \frac{(19{,}270-7{,}063)/12}{(\ 7{,}063)/(74-24)} = 7.20$$

Since F = 7.20 well exceeds F_c (12,60) = 2.50 at a one percent significance level, we reject the hypothesis that the sets of coefficients in the inventory demand equations for the two subperiods are equivalent.

To help confirm the results of the Chow test, we estimated equation 6-2 using the dummy variable approach and obtained, using OLS with the Cochrane-Orcutt procedure:

$$\begin{aligned}
Q^i_t = {} & \underset{\substack{(41.5)\\ -1.3}}{54.81} + \underset{\substack{(39.9)\\ 0.9}}{37.55}\, D_1 + \underset{\substack{(6.7)\\ 2.4}}{15.78}\,(P^e_{t+1}-P_t) \\
& - \underset{\substack{(16.7)\\ -0.4}}{7.17}\, D_1\,(P^e_{t+1}-P_t) + \underset{\substack{(0.1)\\ 17.6}}{1.68}\, Q^i_{t-1} + \underset{\substack{(0.09)\\ 0.2}}{0.02}\, D_1 Q^i_{t-1} \\
& - \underset{\substack{(0.08)\\ -9.0}}{0.76}\, Q^i_{t-2} - \underset{\substack{(0.07)\\ -0.5}}{0.04}\, D_1 Q^i_{t-2} - \underset{\substack{(0.56)\\ -1.0}}{0.59}\, Y_t
\end{aligned}$$

$$
\begin{array}{lll}
-0.20\ D_1Y_t & +0.51\ Y_{t-1} & -0.33\ D_1Y_{t-1} \\
(0.34) & (1.02) & (0.35) \\
-0.3 & 0.5 & -0.9 \\
\\
+0.57\ Y_{t-2} & +0.41\ D_1Y_{t-2} & +1.07\ \Delta P_t \\
(0.62) & (0.26) & (0.80) \\
0.9 & 1.6 & 1.3 \\
\\
-15.05\ D_{s1} & -11.32\ D_{s2} & -13.29\ D_{s3} \\
(4.5) & (1.9) & (3.9) \\
-3.4 & -5.8 & -3.4
\end{array}
$$

$$
\begin{array}{l}
+1.93\ D_e \\
(3.6) \\
0.5
\end{array}
\qquad (6\text{-}5)
$$

N	= 79	SEE	= 13.7
RSS	= 11,270	R^2	$\cong$ 1.00
F(18,60)	= 5,077	$\bar{R}^2$	$\cong$ 1.00
Rho	= -0.136		

D_1 is a dummy variable where $D_1=1$ if the observation lies in the first subperiod and $D_1=0$ if the observation lies in the second subperiod.

The R^2, $\bar{R}^2$ and F statistics for equation 6-5 are statistically acceptable. The results suggest that the coefficients of the price spread ($P^e_{t+1} - P_t$) for the two subperiods are about equivalent. The t-statistic of the non-differential price spread coefficient is significant at about a 99 percent confidence level, while the t-statistic of the differential component is relatively insignificant. This finding is questionable, however, since the t-statistic of the coefficient of the price spread in equation 6-4 for the second subperiod

was significant at a confidence level of about 99 percent, while that for the price spread coefficient in equation 6-3 for the first subperiod was insignificant. Equation 6-5 also indicates that the coefficients of Q^i_{t-1} and Q^i_{t-2} are equivalent for the two subperiods, and this appears intuitively correct on the basis of the estimated coefficients for these variables in equations 6-3 and 6-4. The coefficients of Y_t for the two subperiods might also be considered equivalent on the basis of the low t-statistic for the differential component in equation 6-5, but this finding is not supported by the estimated coefficients in equations 6-3 and 6-4. In particular, the signs of Y_t, Y_{t-1}, and Y_{t-2} in equation 6-3 are opposite to those in equation 6-4. Equation 6-5, however, confirms the differences in the coefficients of Y_{t-1} and Y_{t-2} indicated by equations 6-3 and 6-4. The results of equation 6-5 are imprecise with respect to the constant term, but a glance at the constants in equations 6-3 and 6-4 suggests that they are different. We consider, however, that the dummy variable technique using the Cochrane-Orcutt procedure in this particular instance is not a statistically acceptable indicator of all of the differences between the two subperiods, particularly since it appears that we would not be able to derive all of the proper coefficients for equations 6-3 and 6-4 from equation 6-5.

Next we estimated the same equation using TSLS. A Cochrane-Orcutt type of correction procedure, however, was also applied to the TSLS regressions by means of Amemiya's method, in which the instrumental

variable transformation is applied to the rho-transformed variables at each iteration.10/ We obtained:

$$
\begin{aligned}
Q^i_t = {} & \underset{(77.8)\ 0.9}{69.19} - \underset{(78.2)\ -0.9}{69.81\ D_1} + \underset{(10.5)\ 1.3}{14.04\ (P^e_{t+1} - P_t)} \\
& - \underset{(26.5)\ -1.8}{48.89\ D_1\ (P^e_{t+1} - P_t)} + \underset{(0.17)\ 10.3}{1.71\ Q^i_{t-1}} - \underset{(0.16)\ -0.2}{0.026\ D_1 Q^i_{t-1}} \\
& - \underset{(0.15)\ -5.4}{0.78\ Q^i_{t-2}} + \underset{(0.14)\ 0.2}{0.03\ D_1 Q^i_{t-2}} - \underset{(0.79)\ -1.1}{0.85\ Y_t} \\
& - \underset{(0.61)\ 1.5}{0.90\ D_1 Y_t} + \underset{(1.2)\ 1.1}{1.35\ Y_{t-1}} - \underset{(0.55)\ -0.5}{0.31\ D_1 Y_{t-1}} \\
& - \underset{(0.82)\ -1.0}{0.82\ Y_{t-2}} + \underset{(0.47)\ 0.3}{0.13\ D_1 Y_{t-2}} - \underset{(1.4)\ -0.4}{0.52\ \Delta P_t} \\
& - \underset{(7.2)\ -2.6}{18.62\ D_{s1}} - \underset{(3.8)\ -2.4}{9.34\ D_{s2}} - \underset{(6.0)\ -1.3}{7.80\ D_{s3}} \qquad (6\text{-}6) \\
& - \underset{(7.2)\ -1.4}{9.74\ D_e}
\end{aligned}
$$

N = 79 SEE = 16.3
RSS = 15,880 R^2 = 0.997
F(18,60) = 1,253 $\bar{R}^2$ = 0.997
Rho = -0.017

Equation 6-6 suggests that the constant terms for the two subperiods and the coefficients of the price spread and Y_t are different for the two subperiods. In addition, it indicates, as did equation 6-5, that the coefficients of Q^i_{t-1} and Q^i_{t-2} are equivalent for the two subperiods. These findings tend to confirm those indicated on the basis of the constant terms and coefficients of equations 6-3 and 6-4. Equation 6-5, however, also indicates that the coefficients of Y_{t-1} and Y_{t-2} are similar for the two subperiods, but these findings are not supported by equations 6-3 and 6-4, nor by equation 6-5. Equation 6-6, like equation 6-5, is not considered to be a statistically acceptable indicator of all of the differences between the two subperiods. We suspect that the difficulties with equations 6-5 and 6-6 may arise either because of the opposite signs of Y_t, Y_{t-1} and Y_{t-2} between the two subperiods, or because the price spread, which contains the futures price, may already have taken account of expectations regarding economic activity. In either case, spurious correlations could possibly have been the cause. We therefore decided to reestimate the equations with the economic activity variables deleted, particularly in case the difficulties arose because of interaction between P^e_{t+1} and Y_t. In summary, however, equations 6-5 and 6-6 support the findings of the Chow test that the coefficients of the inventory demand equation for the two subperiods are not equivalent.

The reestimation of equations 6-2, 6-3 and 6-4, with the economic activity variables deleted, produced the following equations. We should note first, however, that we again used a Cochrane-Orcutt correction with our OLS regressions given a statistically unacceptable H-statistic of -3.83 for the OLS estimation of the equation for the full period without the Cochrane-Orcutt correction. The H-statistic is "statistically unacceptable" since it falls outside of the critical value of ± 1.645 required for a 95 percent confidence level that the error terms are serially independent. In addition, we obtained a Rho (diagnostic) statistic of -0.180 for this equation and a Rho (diagnostic) statistic of -0.162 for the OLS estimations for the first subperiod implying the possible existence of impure, first-order autocorrelation. The summary statistics for the second subperiod, however, were statistically acceptable.

(i) January 1975 to December 1981:

$$
\begin{aligned}
Q^i_t = {} & \underset{\substack{(11.1)\\ 2.9}}{32.21} + \underset{\substack{(7.4)\\ 0.4}}{2.71}\,(P^e_{t+1}-P_t) + \underset{\substack{(0.09)\\ 16.2}}{1.50}\,Q^i_{t-1} \\
& - \underset{\substack{(0.09)\\ -6.2}}{0.58}\,Q^i_{t-2} - \underset{\substack{(1.34)\\ -0.5}}{0.63}\,\Delta P_t - \underset{\substack{(5.0)\\ -3.3}}{16.54}\,D_{s1} \\
& - \underset{\substack{(4.2)\\ -2.4}}{10.01}\,D_{s2} - \underset{\substack{(4.3)\\ -3.0}}{12.76}\,D_{s3} - \underset{\substack{(6.3)\\ -1.1}}{7.27}\,D_e \qquad (6\text{-}7)
\end{aligned}
$$

N	= 79	SEE	= 17.6
RSS	= 21,560	R^2	= 0.94
F(8,70)	= 149.3	$\bar{R}^2$	= 0.94
Rho	= 0.011		

(ii) January 1975 to June 1978:

$$Q^i_t = \underset{(14.3)\ 2.5}{35.55} \underset{(20.3)\ -0.1}{- 15.54(P^e_{t+1}-P_t)} + \underset{(0.12)\ -4.0}{1.64\ Q^i_{t-1}}$$

$$\underset{(0.12)\ -5.6}{- 0.68\ Q^i_{t-2}} \underset{(2.39)\ -0.1}{- 0.31\ \Delta P_t} \underset{(6.4)\ -4.0}{- 25.35 D_{s1}}$$

$$\underset{(5.6)\ -3.0}{- 17.03\ D_{s2}} \underset{(6.1)\ -3.2}{- 19.28\ D_{s3}} \underset{(8.2)\ 0.6}{+ 5.25\ D_e} \qquad (6\text{-}8)$$

N = 37 SEE = 18.0
RSS = 9,115 R^2 = 0.98
F(8,28) = 197.9 $\bar{R}^2$ = 0.98
Rho = 0.054

(iii) July 1978 to December 1981:

$$Q^i_t = \underset{(2.4)\ 9.7}{23.13} \underset{(3.8)\ 2.1}{+ 7.87\ (P^e_{t+1}-P_t)} + \underset{(0.04)\ 50.0}{1.80\ Q^i_{t-1}}$$

$$\underset{(0.03)\ -25.9}{- 0.87\ Q^i_{t-2}} \underset{(0.47)\ 1.1}{+ 0.54\ \Delta P_t} \underset{(3.7)\ -4.7}{- 17.38\ D_{s1}}$$

$$\underset{(1.1)\ -4.7}{- 5.05\ D_{s2}} \underset{(3.0)\ -5.0}{- 15.18\ D_{s3}} \underset{(1.0)\ -6.6}{- 6.44\ D_e} \qquad (6\text{-}9)$$

N = 37 SEE = 7.6
RSS = 1,636 $R^2 \cong 1.00$
F(8,28) = 8,001 $\bar{R}^2 \cong 1.00$
Rho = -0.276

The R^2, $\bar{R}^2$ and F statistics for the three equations are all statistically acceptable. An incorrect sign was obtained for the

coefficient of P_t in equation 6-8 for the first subperiod, but its t-statistic is not very significant. Nevertheless, it does suggest the possibility of specification errors.

The F-statistic for the Chow test is:

$$F = \frac{(21{,}560-10{,}751)/9}{10{,}751/(74-18)} = 6.26.$$

Since F = 6.26 far exceeds $F_c(9,60) = 2.72$ at a one percent significance level, we again reject the hypothesis that the sets of coefficients for the two subperiods are equivalent.

To confirm the Chow test, we applied the dummy variable technique to equation 6-7, using OLS with the Cochrane-Orcutt procedure, and obtained:

$$\begin{aligned} Q^i_t = {} & \underset{\substack{(8.1)\\ 3.3}}{26.69} + \underset{\substack{(13.5)\\ 2.4}}{32.72}\, D_1 + \underset{\substack{(7.0)\\ 1.3}}{9.33}\,(P^e_{t+1} - P_t) \\ & - \underset{\substack{(19.2)\\ -1.5}}{29.41}\, D_1\,(P^e_{t+1} - P_t) + \underset{\substack{(0.08)\\ 20.8}}{1.67}\, Q^i_{t-1} - \underset{\substack{(0.05)\\ -2.3}}{0.12}\, D_1 Q^i_{t-1} \\ & - \underset{\substack{(0.08)\\ -9.7}}{0.76}\, Q^i_{t-2} + \underset{\substack{(0.04)\\ 2.8}}{0.10}\, D_1 Q^i_{t-2} - \underset{\substack{(1.16)\\ -0.3}}{0.30}\, \Delta P_t \\ & - \underset{\substack{(4.3)\\ -3.8}}{16.20}\, D_{s1} - \underset{\substack{(3.4)\\ -2.8}}{9.39}\, D_{s2} - \underset{\substack{(3.7)\\ -3.7}}{13.64}\, D_{s3} \end{aligned} \qquad (6\text{-}10)$$

$$- 3.00\ D_e$$
$$(4.7)$$
$$-0.6$$

N	= 79	SEE	= 16.4
RSS	= 17,740	R^2	= 0.98
F(12,66)	= 343.5	$\bar{R}^2$	= 0.98
Rho	= 0.037		

In addition, we reestimated equation 6-10 using TSLS with the Amemiya correction procedure for autocorrelation and obtained:

$$Q^i_t = \underset{(6.7)\ 2.8}{18.79} + \underset{(12.4)\ 2.1}{26.59\ D_1} + \underset{(7.9)\ 1.9}{15.02\ (P^e_{t+1} - P_t)}$$

$$\underset{(21.2)\ -2.7}{- 56.94\ D_1\ (P^e_{t+1} - P_t)} + \underset{(0.08)\ 21.4}{1.73\ Q^i_{t-1}}$$

$$\underset{(0.05)\ -0.1}{- 0.003\ D_1\ Q^i_{t-1}} - \underset{(0.07)\ -10.6}{0.79\ Q^i_{t-2}} + \underset{(0.04)\ 0.6}{0.03\ D_1\ Q^i_{t-2}}$$

$$\underset{(1.22)\ -0.5}{- 0.60\ \Delta P_t} - \underset{(6.9)\ -3.2}{21.77\ D_{s1}} - \underset{(3.1)\ -3.1}{9.71\ D_{s2}}$$

$$\underset{(5.9)\ -2.0}{- 11.58\ D_{s3}} - \underset{(4.2)\ -1.5}{6.30\ D_e} \qquad (6\text{-}11)$$

N	= 79	SEE	= 16.5
RSS	= 18,030	R^2	= 0.997
F(12,66)	= 1,571	$\bar{R}^2$	= 0.997
Rho	= -0.003		

The summary statistics for equations 6-10 and 6-11 are statistically acceptable, and the coefficients in the two equations are reasonably similar. The results confirm the Chow test. As indicated by the t-statistics for the differential coefficients and also their magnitudes, the differences between the two equations rest with the constant terms and the coefficients of the price spread.

Primary Supply

When estimating equation 5-22 for the second subperiod, we found that when we included XP_{t-2} in the equation as an independent variable, we obtained a t-statistic for XP_{t-2} of -2.34, which is significant at about a 99 percent confidence level. We therefore left XP_{t-2} in the equation as an explanatory variable, recognizing that doing so would imply a more complex distributed lag effect of P_t and ΔP_t on XP_t. Following the same procedure we used for inventory demand, we also estimated the equation with XS_t and XC_t lagged two times to accord with the lag on XP_t. Except for XC_{t-1}, however, we found the lagged values to have low t-statistics, and therefore we deleted them from the equation. For the second subperiod, we obtained a Rho (diagnostic) statistic of -0.11, implying the possible existence of first-order autocorrelation that may be impure, but also a statistically acceptable H-statistic of -1.46, which falls within the critical value of $\pm$ 1.645 required for a 95 percent confidence level that the error terms are

serially independent. Our OLS estimations for the full period and for the first subperiod, however, produced statistically unacceptable H-statistics of 2.855 and 2.462, respectively. We therefore decided to use the Cochrane-Orcutt procedure which, for the second subperiod, led to a fall in the residual sum of squares from 3,558 to 1,676, to an increase in the F-statistic from 30.6 to 672.7, and to an increase in $\bar{R}^2$ from 0.888 to 0.995.

The regression results using OLS with the Cochrane-Orcutt procedure were as follows:

(i) January 1975 to December 1981:

$$
\begin{aligned}
XP_t = {} & 37.04 + 0.43\,P_t + 0.08\,XP_{t-1} + 0.05\,XP_{t-2} \\
& (63.4) \quad (0.4) \quad (0.07) \quad (0.07) \\
& 0.6 \quad 1.0 \quad 1.1 \quad 0.8 \\
& + 0.33\,XS_t + 40.60\,XC_t - 28.96\,XC_{t-1} \\
& (0.15) \quad (18.9) \quad (19.4 \\
& 2.1 \quad 2.1 \quad -1.5 \\
& - 0.05\,\Delta P_t + 6.44\,D_{s1} + 5.59\,D_{s2} \\
& (0.08) \quad (4.6) \quad (5.1) \\
& 0.07 \quad 1.4 \quad 1.1 \\
& - 11.40\,D_{s3} - 54.84\,D_e \qquad (6\text{-}12) \\
& (4.6) \quad (6.7) \\
& -2.5 \quad -8.2
\end{aligned}
$$

N	= 79	SEE	= 12.9
RSS	= 11,170	R^2	= 0.76
F(11,67)	= 19.6	$\bar{R}^2$	= 0.76
Rho	= 0.007		

(ii) January 1975 to June 1978:

$$XP_t = \underset{(128.7)\ -0.6}{-\ 85.28} + \underset{(1.1)\ 3.7}{4.02\ P_t} - \underset{(0.08)\ -3.1}{0.26\ XP_{t-1}} - \underset{(0.1)\ -0.3}{0.03\ XP_{t-2}}$$

$$+ \underset{(0.5)\ 3.8}{2.07\ X^s_t} + \underset{(40.0)\ 0.6}{25.01\ X^c_t} - \underset{(39.9)\ -0.4}{15.06\ X^c_{t-1}}$$

$$+ \underset{(1.9)\ 3.6}{6.66\ \Delta P_t} + \underset{(5.7)\ 1.1}{6.46\ D_{s1}} - \underset{(7.1)\ -0.7}{4.82\ D_{s2}}$$

$$- \underset{(7.0)\ -2.7}{18.69\ D_{s3}} - \underset{(10.7)\ -1.6}{17.22\ D_e} \qquad (6\text{-}13)$$

N = 37 SEE = 10.8
RSS = 2,888 R^2 = 0.89
F(11,25) = 17.8 $\bar{R}^2$ = 0.84
Rho = 0.131

(iii) July 1978 to December 1981:

$$XP_t = \underset{(54.3)\ 3.8}{206.2} - \underset{(0.09)\ -0.2}{0.02\ P_t} + \underset{(0.09)\ 4.8}{0.44\ XP_{t-1}} - \underset{(0.06)\ -4.0}{0.23\ XP_{t-2}}$$

$$- \underset{(0.05)\ 0.8}{0.04\ X^s_t} + \underset{(26.6)\ 0.9}{23.37\ X^c_t} - \underset{(28.5)\ -1.6}{44.63\ X^c_{t-1}}$$

$$+ \underset{(0.4)\ 4.0}{1.75\ \Delta P_t} - \underset{(3.7)\ -1.7}{6.19\ D_{s1}} + \underset{(2.3)\ 0.7}{1.54\ D_{s2}}$$

$$- \underset{(4.2)\ -3.9}{16.54\ D_{s3}} - \underset{(5.2)\ -11.9}{61.26\ D_e} \qquad (6\text{-}14)$$

N = 37 SEE = 8.2
RSS = 1,676 R^2 = 0.997
F(11,25) = 672.7 $\bar{R}^2$ = 0.995
Rho = -0.077

The R^2 and $\bar{R}^2$ statistics are all statistically acceptable, particularly for equation 6-14 for the second subperiod, and the F statistics all exceed the critical values at the 99 percent confidence level. An incorrect sign was obtained for the coefficient of P_t in equation 6-14, but the coefficient is almost zero and its t-statistic is not significant.

The F-statistic for the Chow test is:

$$F = \frac{6,606/12}{4,564/(74-24)} = 6.03$$

Since F = 6.03 well exceeds F_c (12,40) = 2.66 at a one percent significance level, we reject the hypothesis that the sets of coefficients for the two subperiods are equivalent.

To confirm the Chow test, and to indicate the nature of the differences between the two subperiods, we applied the dummy variable technique using OLS with the Cochrane-Orcutt procedure to equation 6-12. We obtained:

$$\begin{array}{lccccc} XP_t = & 259.65 & - & 269.60\ D_1 & - & 0.34\ P_t & + 2.54\ D_1P_t \\ & (189.2) & & (211.1) & & (0.54) & (1.1) \\ & 1.4 & & -1.3 & & -0.6 & 2.4 \end{array}$$

$$
\begin{array}{llll}
+\ 0.38\ XP_{t-1} & -\ 0.53\ D_1\ XP_{t-1} & -\ 0.21\ XP_{t-2} & +\ 0.18\ D_1XP_{t-2} \\
(0.09) & (0.13) & (0.07) & (0.08) \\
4.3 & -4.2 & -2.9 & 2.3
\end{array}
$$

$$
\begin{array}{lll}
+\ 0.50\ X^s_t & +\ 0.54\ D_1X^s_t & +\ 20.11\ X^c_t \\
(0.19) & (0.45) & (32.5) \\
2.7 & 1.2 & 0.6
\end{array}
$$

$$
\begin{array}{lll}
+\ 38.13\ D_xX^c_t & -\ 55.24\ X^c_{t-1} & +\ 9.98\ D_1X^c_{t-1} \\
(46.0) & (25.7) & (4.3) \\
0.8 & -2.2 & 2.3
\end{array}
$$

$$
\begin{array}{lll}
+\ 0.06\ \Delta P_t & -\ 2.25\ D_{s1} & +\ 1.35\ D_{s2} \\
(0.77) & (4.5) & (5.3) \\
0.07 & -0.5 & 0.3
\end{array}
$$

$$
\begin{array}{ll}
-\ 14.84\ D_{s3} & -\ 52.37\ D_e \\
(4.5) & (7.2) \\
-3.3 & -7.2
\end{array}
\qquad (6\text{-}15)
$$

N	= 79	SEE	= 11.9
RSS	= 8,435	R^2	= 0.82
F(18,60)	= 15.6	$\bar{R}^2$	= 0.77
Rho	= -0.001		

The summary statistics for equation 6-15 are statistically acceptable. An incorrect sign was obtained for the coefficient of P_t, but the coefficient is small and has a t-statistic that is not significant. The equation confirms the finding of the Chow test that the sets of coefficients for the two subperiods are not equivalent. The t-statistics for all of the differential coefficients, including the constant term, are significant in either absolute terms or relative to the corresponding non-differential coefficients.

We reestimated equation 6-15 using TSLS with the Amemiya procedure, and obtained:

$$
\begin{aligned}
XP_t = {} & \underset{\substack{(189.9)\\ 1.3}}{247.77} - \underset{\substack{(210.3)\\ -1.5}}{315.94\, D_1} - \underset{\substack{(0.52)\\ -0.7}}{0.36\, P_t} + \underset{\substack{(1.0)\\ 2.6}}{2.77\, D_1P_t} \\
& + \underset{\substack{(0.09)\\ 4.0}}{0.38\, XP_{t-1}} - \underset{\substack{(0.14)\\ -3.8}}{0.51\, D_1XP_{t-1}} - \underset{\substack{(0.08)\\ -2.5}}{0.20\, XP_{t-2}} + \underset{\substack{(0.08)\\ 2.7}}{0.23\, D_1XP_{t-2}} \\
& + \underset{\substack{(0.20)\\ 2.6}}{0.51\, X^s_t} + \underset{\substack{(0.47)\\ 1.5}}{0.69\, D_1X^s_t} + \underset{\substack{(33.5)\\ 0.5}}{17.30\, X^c_t} + \underset{\substack{(45.6)\\ 1.0}}{46.69\, D_1X^c_t} \\
& - \underset{\substack{(26.8)\\ -1.9}}{50.21\, X^c_{t-1}} + \underset{\substack{(4.7)\\ 1.7}}{7.96\, D_1X^c_{t-1}} + \underset{\substack{(0.82)\\ 0.9}}{0.71\, \Delta P_t} \\
& - \underset{\substack{(4.8)\\ -0.5}}{2.33\, D_{s1}} - \underset{\substack{(5.7)\\ -0.3}}{1.70\, D_{s2}} - \underset{\substack{(4.8)\\ -3.4}}{16.12\, D_{s3}} - \underset{\substack{(7.7)\\ -6.8}}{52.26\, D_e} \qquad (6\text{-}16)
\end{aligned}
$$

N = 79 SEE = 12.0
RSS = 8,656 R^2 = 0.83
F(18,60) = 16.3 $\bar{R}^2$ = 0.77
Rho = -0.010

The summary statistics for equation 6-16 are statistically acceptable. The coefficients in the equation are all close to those obtained in equation 6-15 for the Cochrane-Orcutt estimation, and their t-statistics tend to confirm our earlier findings that the sets of coefficients for the two subperiods are not equivalent.

Secondary Supply

When estimating equation 5-23 with OLS for the second subperiod, we found that when we added secondary supply lagged twice (X^S_{t-2}) to the equation as an explanatory variable, it had a highly significant t-statistic. We therefore decided to leave this variable in the equation. We also lagged XP_t to enable it to express independent lag behavior. We found, however, that XP_t only needed to be lagged once to achieve this objective. The scrap price (P^S_t) was not lagged since we considered that it would be more appropriate for this variable to be subject to the same constraints as the other price variables (P_t and ΔP_t. The sign of P_t was negative, and therefore theoretically incorrect, but its t-statistic of -0.59 was not statistically significant. An H-statistic for the regression was not calculated by the computer program, but the Rho (diagnostic) statistic was almost zero. For the full period, however, we obtained a statistically unacceptable H-statistic of -1.834. We therefore decided to use the Cochrane-Orcutt procedure in our subsequent regressions. In doing so we found that, in the equation for the second subperiod (refer equation 6-19), the sign of P_t became positive.

Our regressions produced the following equations:

(i) January 1975 to December 1981:

$$\begin{array}{lccccccc} X^S_t = & - & 4.42 & - & 0.35\ P_t & + & 0.71\ X^S_{t-1} & + & 0.24\ X^S_{t-2} \\ & & (4.4) & & (0.27) & & (0.11) & & (0.10) \\ & & -1.0 & & -1.3 & & 6.7 & & 2.3 \end{array}$$

$$+ \underset{(0.04)\ 4.4}{0.19\ XP_t} - \underset{(0.04)\ -4.3}{0.16\ XP_{t-1}} + \underset{(0.36)\ 1.6}{0.56\ P^s_t}$$

$$- \underset{(0.45)\ -1.7}{0.76\ \Delta P_t} + \underset{(2.4)\ 0.6}{1.52\ D_{s1}} + \underset{(1.6)\ 0.5}{0.73\ D_{s2}}$$

$$- \underset{(2.5)\ -0.04}{0.11\ D_{s3}} + \underset{(2.4)\ 0.6}{1.40\ D_e} \qquad (6\text{-}17)$$

N = 79 SEE = 6.7
RSS = 3,043 R^2 = 0.97
F(11,67) = 172.1 $\bar{R}^2$ = 0.96
Rho = -0.029

(ii) January 1975 to June 1978:

$$X^s_t = \underset{(10.6)\ 3.6}{38.58} - \underset{(0.7)\ -2.9}{2.06\ P_t} - \underset{(0.13)\ -1.8}{0.24\ X^s_{t-1}} + \underset{(0.10)\ 2.1}{0.21\ X^s_{t-2}}$$

$$+ \underset{(0.04)\ 3.7}{0.14\ XP_t} + \underset{(0.03)\ 3.4}{0.11\ XP_{t-1}} + \underset{(0.9)\ 1.4}{1.27\ P^s_t}$$

$$- \underset{(0.4)\ -3.6}{1.54\ \Delta P_t} + \underset{(1.67)\ 0.2}{0.31\ D_{s1}} + \underset{(2.0)\ 2.2}{4.30\ D_{s2}}$$

$$+ \underset{(1.8)\ 2.9}{5.24\ D_{s3}} - \underset{(2.7)\ -2.3}{6.24\ D_e} \qquad (6\text{-}18)$$

N = 37 SEE = 2.9
RSS = 203.5 R^2 = 0.88
F(11,25) = 16.9 $\bar{R}^2$ = 0.83
Rho = -0.043

(iii) July 1978 to December 1981:

$$X^s_t = \underset{(17.6)\ 1.1}{19.05} + \underset{(0.48)\ 1.9}{0.92\ P_t} + \underset{(0.14)\ 5.6}{0.78\ X^s_{t-1}} + \underset{(0.16)\ 0.8}{0.12\ X^s_{t-2}}$$

$$
\begin{array}{llll}
+ & 0.07\ XP_t & - 0.19\ XP_{t-1} & - 1.12\ P^s{}_t \\
 & (0.12) & (0.04) & (0.67) \\
 & 0.6 & -4.6 & -1.7 \\
 & & & \\
- & 2.05\ \Delta P_t & + 8.64\ D_{s1} & + 9.12\ D_{s2} \\
 & (0.5) & (5.1) & (2.7) \\
 & -3.9 & 1.7 & 3.4 \\
 & & & \\
+ & 4.35\ D_{s3} & - 11.16\ D_1 & \\
 & (5.6) & (8.6) & \\
 & 0.8 & -1.3 &
\end{array}
\qquad (6\text{-}19)
$$

N	= 37	SEE	= 7.2
RSS	= 1,305	R^2	= 0.96
F(11,25)	= 59.8	$\bar{R}^2$	= 0.95
Rho	= -0.285		

The summary statistics for the three equations are statistically acceptable. In equation 6-18, incorrect signs were generated for P_t and $P^s{}_t$, and their coefficients have significant t-statistics. These same problems arose with equation 6-15, suggesting that equation 6-18 could possibly be misspecified.

The F-statistic for the Chow test is:

$$F = \frac{1534.5/12}{(1508.5)/(74-24)} = 4.24$$

Since F = 4.24 well exceeds F_c (12,40) = 2.66 at a one percent significance level, we reject the hypothesis that the regression coefficients for the two subperiods are equivalent.

In view of the possible misspecification of our equation for the first subperiod, which tends to support the finding of the Chow test, we decided not to use the dummy variable technique to confirm the Chow test.

Demand for Deliveries

We incorporated a distributed lag effect of P_t and ΔP_t in equation 5-24 by adding deliveries (X^d_t) lagged once as an explanatory variable, in order to enable the equation to exhibit dynamic behavior. Accordingly, we also lagged the other explanatory variables, Y_t and pal_t, one time to enable them to express independent lag behavior. In our OLS regressions for the second subperiod, X^d_{t-1} had a low t-statistic of about 0.70, but the Rho (diagnostic) statistic of -0.142 indicated that first-order autocorrelation may be present. The computer program did not calculate an H-statistic for the equation to enable us to confirm or deny the presence of significant autocorrelation. A statistically unacceptable H-statistic of -4.933, however, was obtained for the OLS estimation for the full period. We therefore decided to estimate our equations using the Cochrane-Orcutt procedure.

Our regression results were as follows:

(i) January 1975 to December 1981:

$$X^d_t = \underset{\substack{(45.0)\\-0.8}}{-\ 37.34} + \underset{\substack{(0.68)\\1.7}}{1.16\ P_t} - \underset{\substack{(0.11)\\-1.8}}{0.19\ X^d_{t-1}} - \underset{\substack{(1.67)\\-0.1}}{0.18\ \Delta P_t}$$

$$- \underset{\substack{(0.55)\\-0.1}}{0.75\ Y_t} + \underset{\substack{(0.53)\\3.1}}{1.64\ Y_{t-1}} - \underset{\substack{(2.3)\\-1.2}}{2.67\ P^{al}_t} + \underset{\substack{(2.3)\\0.4}}{0.94\ P^{al}_{t-1}}$$

$$+ \underset{\substack{(6.2)\\3.4}}{20.80\ D_{s1}} + \underset{\substack{(7.0)\\3.0}}{21.39\ D_{s2}} + \underset{\substack{(6.0)\\0.5}}{3.19\ D_{s3}} - \underset{\substack{(9.0)\\-4.4}}{39.66\ D_e} \qquad (6\text{-}20)$$

N = 79 SEE = 16.0
RSS = 17,190 R^2 = 0.58
F(11,67) = 8.5 $\bar{R}^2$ = 0.51
Rho = 0.031

(ii) January 1975 to June 1978:

$$X^d_t = \underset{\substack{(80.6)\\-1.3}}{-\ 106.05} + \underset{\substack{(1.5)\\0.9}}{1.32\ P_t} + \underset{\substack{(0.16)\\0.5}}{0.08\ X^d_{t-1}} - \underset{\substack{(3.12)\\-1.2}}{3.71\ \Delta P_t}$$

$$+ \underset{\substack{(1.21)\\0.7}}{0.89\ Y_t} + \underset{\substack{(1.26)\\0.6}}{0.73\ Y_{t-1}} - \underset{\substack{(3.8)\\-1.9}}{7.19\ P^{al}_t} + \underset{\substack{(4.0)\\1.5}}{6.04\ P^{al}_{t-1}}$$

$$+ \underset{\substack{(10.1)\\2.0}}{20.04\ D_{s1}} + \underset{\substack{(11.1)\\1.7}}{18.43\ D_{s2}} + \underset{\substack{(11.3)\\0.9}}{9.67\ D_{s3}} - \underset{\substack{(13.9)\\-3.3}}{45.34\ D_e} \qquad (6\text{-}21)$$

N = 37 SEE = 17.1
RSS = 7,272 R^2 = 0.77
F(11,25) = 7.7 $\bar{R}^2$ = 0.67
Rho = -0.039

(iii) July 1978 to December 1981:

$$X^d_t = \underset{\substack{(71.9)\\-2.0}}{-\ 141.71} - \underset{\substack{(0.63)\\-0.5}}{0.32\ P_t} + \underset{\substack{(0.13)\\1.0}}{0.13\ X^d_{t-1}} + \underset{\substack{(1.8)\\1.2}}{2.24\ \Delta P_t}$$

$$
\begin{array}{llll}
+\ 0.46\ Y_t & +\ 1.24\ Y_{t-1} & -\ 1.28\ P^{al}{}_t & +\ 1.73\ P^{al}{}_{t-1} \\
\quad (0.55) & \quad (0.67) & \quad (2.48) & \quad (2.22) \\
\quad 0.8 & \quad 1.8 & \quad -0.5 & \quad 0.8
\end{array}
$$

$$
\begin{array}{llll}
+\ 10.43\ D_{s1} & +\ 7.44\ D_{s2} & -\ 3.00\ D_{s3} & -\ 31.55\ D_e \\
\quad (4.4) & \quad (4.8) & \quad (3.4) & \quad (8.3) \\
\quad 2.4 & \quad 1.6 & \quad -0.9 & \quad -3.8
\end{array}
\qquad (6\text{-}22)
$$

N	= 37	SEE	= 10.8
RSS	= 2938	R^2	= 0.95
F(11,25)	= 44.7	$\bar{R}^2$	= 0.93
Rho	= -0.105		

The summary statistics for the three regressions were statistically acceptable except for the low R^2 and $\bar{R}^2$ statistics generated for equation 6-20. Of greater importance, however, equations 6-20 and 6-21 have incorrect signs for P_t, and point to possible specification errors for the first subperiod.

The F-statistic for the Chow test is:

$$F = \frac{(17{,}190 - 10{,}210)/12}{(10{,}210)/\ (74\text{-}24)} = 2.85$$

Since F = 2.85 exceeds F_c (12,40) = 2.66 at a one percent significance level, we reject the hypothesis that the two sets of coefficients are equivalent. Given the possible misspecification of equation 6-21, the dummy variable technique was not used to confirm the Chow test.

Demand for Net Imports

We incorporated a distributed lag effect of P_t and ΔP_t on demand for net imports by including X^m_{t-1} in the equation as an explanatory variable. We did this to enable the equation to exhibit dynamic behavior, and also because the t-statistic of X^m_{t-1} for the second subperiod, when estimated with OLS, was found to be highly significant at 3.81. The equation, however, also had an H-statistic of -1.723, which falls outside the limit of $\pm$ 1.625 required for a 95 percent confidence level that the error terms are serially independent. In addition, our OLS regressions for the full period and the first subperiod also had statistically unacceptable H-statistics. We therefore applied a Cochrane-Orcutt correction to our OLS regressions.

Using the Cochrane-Orcutt procedure, we obtained the following equations:

(i) January 1975 to December 1981:

$$
\begin{aligned}
X^m_t = &- \underset{\substack{(7.94)\\-0.3}}{2.55} + \underset{\substack{(1.3)\\1.9}}{2.47}\, P_t - \underset{\substack{(1.2)\\-1.9}}{2.28}\, P^{lme}_t + \underset{\substack{(0.05)\\14.2}}{0.79}\, X^m_{t-1} \\
&+ \underset{\substack{(1.1)\\0.04}}{0.04}\, \Delta P_t + \underset{\substack{(3.2)\\0.6}}{2.00}\, D_{s1} + \underset{\substack{(3.0)\\1.1}}{3.33}\, D_{s2} \\
&- \underset{\substack{(3.0)\\-0.9}}{2.65}\, D_{s3} + \underset{\substack{(3.5)\\2.6}}{9.07}\, D_e
\end{aligned}
\qquad (6\text{-}23)
$$

N = 79 SEE = 11.5
RSS = 9,205 R^2 = 0.82
F(8,70) = 38.9 $\bar{R}^2$ = 0.80
Rho = 0.010

(ii) January 1975 to June 1978:

$$X^m_t = \underset{(6.6)\ 2.6}{17.17} + \underset{(1.5)\ 3.4}{4.96\ P_t} - \underset{(1.4)\ -4.0}{5.48\ P^{lme}_t} + \underset{(0.03)\ 27.1}{0.86\ X^m_{t-1}}$$

$$- \underset{(1.1)\ -2.6}{2.91\ \Delta P_t} - \underset{(3.4)\ -0.2}{0.74\ D_{s1}} + \underset{(1.8)\ 3.1}{5.48\ D_{s2}}$$

$$- \underset{(3.4)\ -0.2}{0.54\ D_{s3}} - \underset{(2.9)\ -0.06}{0.19\ D_e} \qquad (6\text{-}24)$$

N = 37 SEE = 10.0
RSS = 2,777 R^2 = 0.99
F(8,28) = 246.0 $\bar{R}^2$ = 0.98
Rho = -0.054

(iii) July 1978 to December 1981:

$$X^m_t = - \underset{(15.7)\ -1.2}{19.10} + \underset{(2.6)\ 1.4}{3.69\ P_t} - \underset{(2.5)\ -1.2}{2.92\ P^{lme}_t} + \underset{(0.15)\ 4.5}{0.67\ X^m_{t-1}}$$

$$+ \underset{(1.4)\ 2.8}{3.91\ \Delta P_t} + \underset{(5.5)\ 1.7}{9.45\ D_{s1}} + \underset{(5.5)\ 0.1}{0.62\ D_{s2}}$$

$$+ \underset{(4.7)\ 1.3}{5.88\ D_{s3}} + \underset{(6.3)\ 1.8}{11.30\ D_e} \qquad (6\text{-}25)$$

N = 37 SEE =10.5
RSS = 3,073 R^2 = 0.65
F(8,28) = 6.6 $\bar{R}^2$ = 0.55
Rho = -0.001

Apart from low R^2 and $\bar{R}^2$ statistics for equation 6-25, the summary statistics are all statistically acceptable. Those for equation 6-24 for the subperiod from January 1975 to June 1978 are particularly notable given the high $\bar{R}^2$ and F statistics that were obtained. Theory indicates that the magnitudes of the coefficients of P_t and $P^{lme}{}_t$ should be equal, and in the above equations we find that they are acceptably close.

Our calculations for the Chow test produced:

$$F = \frac{3,355/9}{(2,777 + 3073)/(74-18)} = 3.57$$

Since F = 3.57 exceeds F_c (9,40) = 2.89 at a one percent significance level, we reject the hypothesis that the two sets of coefficients are equivalent.

To confirm the Chow test, and to indicate where the differences lie, we estimated equation 6-23 using the dummy variable technique. Our results, using OLS with the Cochrane-Orcutt procedure, were:

$$\begin{array}{lccccccc} X^m{}_t = & - & 11.20 & + & 14.68\ D_1 & + & 2.47\ P_t & - 2.16\ P^{lme}{}_t \\ & & (7.5) & & (12.1) & & (1.8) & (1.7) \\ & & -1.5 & & 1.2 & & 1.4 & -1.3 \end{array}$$

$$+ \underset{\substack{(3.3)\\1.7}}{5.61}\, D_1P_t - \underset{\substack{(3.1)\\-1.9}}{5.99}\, D_1P^{lme}{}_t + \underset{\substack{(0.08)\\12.3}}{0.93}\, X^m{}_{t-1}$$

$$- \underset{\substack{(0.09)\\-2.1}}{0.18}\, D_1X^m{}_{t-1} - \underset{\substack{(1.11)\\-0.4}}{0.39}\, \Delta P_t + \underset{\substack{(3.2)\\0.5}}{1.60}\, D_{s1}$$

$$+ \underset{\substack{(2.5)\\2.4}}{6.05}\, D_{s2} + \underset{\substack{(3.1)\\0.1}}{0.45}\, D_{s3} + \underset{\substack{(3.0)\\1.5}}{4.60}\, D_e \qquad (6\text{-}26)$$

N	= 79	SEE	= 11.3
RSS	= 8,446	R^2	= 0.91
F(12,66)	= 55.9	$\bar{R}^2$	= 0.89
Rho	= -0.011		

The summary statistics for equation 6-26 are all statistically acceptable. The equation confirms the results of the Chow test since the t-statistics for all the differential coefficients, including the constant term, are reasonably significant.

We reestimated equation 6-26 using TSLS with the Amemiya procedure. The results were:

$$X^m{}_t = \underset{\substack{(8.4)\\-1.0}}{-8.41} + \underset{\substack{(13.5)\\0.9}}{12.11}\, D_1 + \underset{\substack{(2.0)\\1.2}}{2.39}\, P_t - \underset{\substack{(1.9)\\-1.1}}{2.15}\, P^{lme}{}_t$$

$$+ \underset{\substack{(3.6)\\1.6}}{5.62}\, D_1P_t - \underset{\substack{(3.5)\\-1.7}}{5.93}\, D_1P^{lme}{}_t + \underset{\substack{(0.09)\\10.2}}{0.92}\, X^m{}_{t-1}$$

$$- \underset{\substack{(0.10)\\-1.8}}{0.18}\, D_1X^m{}_{t-1} - \underset{\substack{(1.2)\\-0.8}}{0.95}\, \Delta P_t - \underset{\substack{(3.5)\\-0.3}}{0.98}\, D_{s1}$$

$$+ \underset{(2.9)}{\underset{2.0}{5.58}}\ D_{s2} - \underset{(3.4)}{\underset{-0.3}{1.02}}\ D_{s3} + \underset{(3.7)}{\underset{1.7}{6.40}}\ D_e \qquad (6\text{-}27)$$

N	= 79	SEE	= 11.4
RSS	= 8,592	R^2	= 0.90
F(12,66)	= 51.4	$\bar{R}^2$	= 0.89
Rho	= -0.006		

The summary statistics for equation 6-27 are all statistically acceptable. The coefficients are close to those obtained for equation 6-26 and their t-statistics support our earlier conclusions that the sets of coefficients for the two subperiods are not equivalent.

Footnotes

Chapter VI

1/ For a comparison of the properties of the OLS estimator versus the TSLS estimator, the interested reader is referred to Cassidy, op.cit., pages 216 to 226.

2/ Hwa, op.cit., page 164.

3/ Walter C. Labys and Clive W.J. Granger, Speculation, Hedging and Commodity Price Forecasts, Health Lexington Books, D.C. Health and Company, Lexington, Mass., 1970, pages 108-109.

4/ Chow, op.cit.

5/ Gujarati, op.cit.

6/ Ibid.

7/ Rao and Miller, op.cit., pages 160-179.

8/ D. Cochrane and G.H. Orcutt, "Applications of Least Squares Regressions to Relationships Containing Auto-Correlated Error Terms," Journal of the American Statistical Association, Vol. 44 (1949), page 32.

9/ For a discussion of the behavior of R^2 under stock versus flow formulations, the reader is referred to Cassidy, op.cit., page 63.

10/ T. Amemiya, "Specification Analysis in the Estimation of Parameters of a Simultaneous Equation Model with Autoregressive Residuals," Econometrica, Vol. 34 (1966), page 283.

Chapter VII

SUMMARY AND CONCLUSIONS

It has been alleged that the major producers of refined copper in the United States have sufficient market power to "administer" their own prices. The producers quote prices for the domestic sale of refined copper in its basic forms, such as wirebars and cathodes, that have often differed from the prices determined in the auction markets such as the London Metal Exchange (LME) and the Commodity Exchange of New York (Comex). From the early 1960s until about mid-1978, the price differences have often been very significant, but since then producer prices have followed auction prices closely.

The price differences prior to mid-1978 arose allegedly because the producers would set the producer price at a level that they considered to be sustainable given their expectations regarding long-run demand and supply, taking into account their own production decisions. They would then attempt to trade copper at the producer price irrespective of current market demand. When excess demand existed at the producer price, the producers would ration available stocks rather than raise the price. Similarly, when there was excess supply at the producer price, they would stock copper rather than lower the price.

They would adjust the price only when they perceived, as a result of either steady inventory stocking, or inventory de-stocking, that the price was not consistent with a sustainable "long-run" price. (As our results will show, we are not able to reject this perception of producer behavior.)

The producers could maintain this pricing behavior allegedly because they have sufficient market power to hinder their customers from engaging in arbitrage when producer prices are below prices in the auction markets, and from switching to the auction markets when producer prices are above auction prices. The producers are thought to derive their market power from the largely self-sufficient position of the United States in copper supplies and the high degree of concentration in the U.S. copper industry. Domestic production of refined copper, for example, accounted for an average of about 97 percent of domestic consumption during the period from 1970 to 1979. In 1978, three companies owned or controlled almost 65 percent of domestic mine production, and owned about 70 percent of the country's total smelter capacity and 60 percent of its major refinery capacity. In addition, seven companies were fully integrated from mining through smelting to refining, and had their own marketing facilities. Together they owned or controlled the bulk of domestic mine production, over 90 percent of total smelter capacity and over 80 percent of total refinery capacity.

There are, however, factors which could constrain or limit the producers' market powers. Domestically, there is the auction market for refined copper which can be fed by non-integrated producers using secondary sources (scrap), and also competition from substitute materials such as aluminum. In addition, there is the ever present threat of competition from imports, since the costs of importing refined copper appear to be relatively low.

In this thesis, we adopted another view of producer pricing behavior. We suggested instead that the producers behave as "price takers" and actually trade refined copper at or near auction prices rather than at their producer prices, either by design or because they do not have sufficient market power to do otherwise. In particular, we hypothesized that the producers traded refined copper at auction prices instead of at producer prices in times when producer prices were significantly different from auction prices prior to mid-1978.

To test this hypothesis, we took advantage of alleged changes in producer pricing policies announced in mid-1978 by some of the major producers, which led to producer prices that were directly related to prices established in the auction markets. This enabled us to formulate a theoretically-consistent econometric model to explain producer behavior for the subperiod from July 1978 to December 1981 assuming that the producers traded refined copper at auction prices. In this regard,

the correlation coefficient between the monthly average U.S. producer price of electrolytic copper, as quoted by "Metals Week," and the Comex spot price of electrolytic copper, was 0.994 for the months from July 1978 to December 1981. (In comparison, it was 0.741 for the months from January 1975 to June 1978.) We then applied our model to the subperiod from January 1975 to June 1978 assuming that the producers traded refined copper at auction prices during this subperiod also. We intended to show, as our hypothesis would suggest, that the coefficients of the equations in the model were equivalent for the two subperiods, since this would provide evidence that the producers also traded refined copper at auction prices prior to mid-1978 and that no structural changes took place between the two subperiods.

Our model comprised a simultaneous system of equations. It contained an equation for the producers' demand for inventories of refined copper (which we referred to as inventory demand), and also equations to explain separately the demand of the semi-fabricating markets for refined copper (demand for deliveries), the supply of refined copper from primary sources (primary supply), the supply of refined copper from secondary sources (secondary supply), and the demand of the U.S. market for net imports of refined copper (demand for net imports). The inventory demand equation was considered to be of particular importance. If the coefficients of this equation did not change, it would indicate that the producers may not have used inventory

policies as a means to administer prices prior to mid-1978, and therefore indicate also that the producers may have traded refined copper at or near auction prices prior to mid-1978. We had to assume, however, that the underlying forces of supply and demand were largely stable from January 1975 to December 1981.

We formulated our model on the basis of the "short-side" or "Fair-Jaffee" methods of estimating supply and demand schedules in disequilibrium markets, as elaborated upon by Roger J. Bowden (1978). Essentially, this approach assumes that if prices do not immediately clear an imbalance of supply and demand, the quantities actually transacted are determined as the minimum of the quantity demanded and the quantity supplied. The equations of the model were estimated in their structural forms on monthly average data separately for the subperiods from January 1975 to June 1978 and from July 1978 to December 1981, and also for the full period from January 1975 to December 1981. This enabled us to apply the Chow test to the sets of coefficients for the two subperiods to test for equivalence. In addition, we applied a dummy variable technique on data for the full period to help confirm and/or elaborate upon the results of the Chow test. The dummy variable technique enabled us to determine if the differences, if any, between the two subperiods rested with the intercept terms of the equations, their slope coefficients, or both.

For the Chow test, we estimated the equations using ordinary least squares (OLS) with a Cochrane-Orcutt iterative correction procedure for autocorrelation, in which the final OLS regression is carried out on the rho-transformed variables. For the dummy variable analysis, we estimated the equations first by using OLS with the Cochrane-Orcutt procedure, and secondly by using two stage least squares (TSLS) with the Amemiya correction procedure for autocorrelation, in which the instrumental variable transformation is applied to the rho-transformed variables at each iteration. Although the equations constituted a simultaneous system, the OLS estimates provided a benchmark on which to compare the TSLS estimates.

The results of our econometric analysis are summarized in Table 7-1. In general, the results do not support our hypothesis that the producers traded refined copper at auction prices prior to mid-1978. For all of the equations, the Chow test rejected the hypothesis, at a one percent significance level, that the sets of coefficients for the first subperiod from January 1975 to June 1978 and for the second subperiod from July 1978 to December 1981 were equivalent. Our dummy variable analysis confirmed the Chow test for the inventory demand, primary supply, and demand for net imports equations.

As shown in Table 7-1, the R^2, $\bar{R}^2$ and F statistics for our OLS regression equations for the second subperiod were both highly

Table 7-1

Econometric Results

Equation	Chow Test: Subperiod [1]	Chow Test: Signs [2]	OLS Results [3]: R^2	OLS Results [3]: $\bar{R}^2$	OLS Results [3]: F	Reject Equivalence of Coefficients	Dummy Variable Analysis: OLS Results [3]	Dummy Variable Analysis: TSLS Results [4]
Inventory Demand [5]	1	C	0.999	0.998	1,693 (11,25)		Confirm Chow test	Confirm Chow test, but the TSLS estimates differ from the OLS estimates
	2	C	1.00	1.00	6,538 (11,25)	Yes		
	3	C	0.92	0.90	67.3 (11,67)			
Primary Supply	1	C	0.89	0.84	17.8 (11,25)		Confirm Chow test; differences in intercept terms and slope coefficients	Confirm Chow test; the TSLS estimates are similar to the OLS estimates
	2	C	0.997	0.995	627.7 (11,25)	Yes		
	3	C	0.76	0.72	19.6 (11,67)			
Secondary Supply	1	I	0.88	0.83	16.9 (11,67)		Not carried out in view of incorrect signs for subperiod 2 under Chow test	
	2	C	0.96	0.95	59.8 (11,25)	Yes		
	3	I	0.97	0.96	172.1 (11,67)			
Demand for Deliveries	1	I	0.77	0.67	7.7 (11,2)		Not carried out in view of incorrect signs for subperiod 2 under Chow test	
	2	C	0.95	0.93	44.7 (11,25)	Yes		
	3	I	0.58	0.51	8.5 (11,67)			
Demand for Net Imports	1	C	0.99	0.98	246.0 (8,28)		Confirm Chow test; differences in intercept terms and slope coefficients	Confirm Chow test; the TSLS estimates are similar to the OLS estimates
	2	C	0.65	0.55	6.6 (8,28)	Yes		
	3	C	0.82	0.80	38.9 (8,70)			

1/ (Sub)period 1: January 1975 to June 1978
2: July 1978 to December 1981
3: January 1975 to December 1981

2/ C: Correct; I: Incorrect.

3/ A Cochrane-Orcutt correction for autocorrelation was used in the OLS estimations.

4/ The Amemiya method of correcting for autocorrelation was used in the TSLS estimations.

5/ The inventory demand equations were estimated in two formulations; only the results of the first (and more complex formulation) are summarized here. The conclusions of the Chow test and the dummy variable analysis are the same for both formulations except that, for the second formulation, the TSLS estimates are similar to the OLS estimates.

significant statistically and also more significant than the corresponding statistics for the equations for the first subperiod, except for the equations for demand for net imports. This suggests that the alleged changes in producer pricing policies after mid-1978, leading to producer prices with greater conformity with those in the auction markets, may have been realities. We suspect that similar results were not obtained for the demand for net imports because refined copper is perhaps imported primarily by market participants other than the major producers. These market participants may also have had particular incentive to import refined copper prior to mid-1978 when the differences between producer prices and auction market prices were often very material. Other indicators of different market behavior between the two periods are suggested by incorrect signs which we obtained for the price variables in our equations for secondary supply and the demand for deliveries in the first subperiod, particularly since their t-statistics were significant.

In summary, our results suggest that the behavior of the producers after mid-1978 was materially different from their behavior prior to that time. It may be that administered producer prices, which we did not reflect in our model, are important to explaining producer behavior prior to mid-1978. If in fact they are, then this would imply, contrary to our hypothesis, that the producers did have sufficient market power to enable them to trade copper at prices significantly

different from those prevailing in the auction markets. Alternatively, our results could be reflecting a possibly invalid assumption or postulation on our part. We assumed, for example, that the state of technology remained constant during the period of estimation from January 1975 to December 1981, and also that the relationships among the variables in the equations of our model were linear. We also made use of simplifying assumptions in postulating some equations, such as the demand for deliveries. In general, we assumed stability in the underlying forces of supply and demand over the period of estimation. In addition, we encountered data limitations in a few instances that necessitated the use of approximations, and our econometric estimations indicated for some equations that relevant variables might possibly be missing. We cannot discount the possibility, therefore, that we may have made an incorrect assumption or an unreliable econometric estimation.

Our equations produced other interesting results that do not bear on our conclusions with respect to our hypothesis, but relate to the elasticities of supply and demand. In the second subperiod, for which our equations appear to have substantial explanatory power, the demand for deliveries and primary and secondary supply in the very short-run (over month-long intervals) all appear to be price inelastic, with primary supply being more inelastic than secondary supply. The cross-elasticity of demand for copper with respect to aluminum also appears to be inelastic. In addition, inventory demand is inelastic

with respect to price, and also inelastic with respect to the price spread between the futures price and the spot price. The demand for net imports, on the other hand, is elastic with respect to price but inelastic with respect to the price spread between the LME price and the Comex price. In general, it appears that small changes in other explanatory variables, such as the economic activity variables in the demand equations, could lead to significant changes in equilibrium prices. These findings generally support those of Charles River Associates and Fisher et al. described in Chapter IV, and help to explain why copper prices in the auction markets have been volatile.

SELECTED BIBLIOGRAPHY

Amemiya, T. "Specification Analysis in the Estimation of Parameters of a Simultaneous Equation Model with Autoregressive Residuals," Econometrica, 1966, Vol. 34, pages 283-306.

Amiercan Metal Market. Metal Statistics. New York: Fairchild Publishing Company, Annual Issues 1977-1982.

Arrow, Kenneth J.; Karlin, Samuel; and Scarf, Herbert., ed. Studies in the Mathematical Theory of Inventory and Production. Stanford: Stanford University Press, 1958.

Bain, J.S. Barriers to New Competition; Cambridge, Mass.: Harvard University Press, 1956.

Banks, Ferdinand E. The World Copper Market: An Economic Analysis. Cambridge, Mass.: Ballinger Publishing Company, 1974.

Bowden, Roger J. The Econonometrics of Disequilibrium. New York: North-Holland Publishing Company, 1978.

Brennan, Michael J. "The Supply of Storage," American Economic Review, March 1958, Vol. 48, pages 50-72.

Bridge, J.L. Aplied Econometrics. Amsterdam: North-Holland Publishing Company, 1971.

Cassidy, Henry J. Using Econometrics; a beginner's guide. Reston, Virginia: Reston Publishing Company, Inc., 1981.

Charles River Associates, Inc. Economic Analysis of the Copper Industry. Washington, D.C.: General Services Administration, March 1970.

Childs, Gerald L. Unfilled Orders and Inventories; a Structural Analysis. Amsterdam: North-Holland Publishing Company, 1967.

Chow, Gregory C. "Tests of Equality between Sets of Coefficients in Two Linear Regressions," Econometrica, July 1960, Vol. 28, No. 3, pages 591-605.

Cochane, D., and Orcutt, G.H. "Applications of Least Squares Regressions to Relationships Containing Auto-Correlated Error Terms," Journal of the American Statistical Association, 1949, Vol. 44, pages 33-61.

Commodity Exchange, Inc. Statistical Yearbook, New York, 1978.

Copper Development Association, Inc. Annual Data 1980, 1980.

Copper Development Association, Inc. Fact Sheet, May 1980.

Fair, Ray C., and Jaffee, Dwight M. "Methods of Estimation for Markets in Disequilibrium," Econometrica, May 1972, Vol. 40, No. 3, pages 497-514.

Fisher, Franklin M., Cootner, Paul H., and Baily, Martin Neil. "An Econometric Model of the World Copper Industry," Bell Journal of Economics and Management Science, Autumn 1972, Vol. 3, No. 2, pages 568-609.

Gluschke, Wolfgang; Shaw, Joseph; and Varon, Bension. Copper: The Next Fifteen Years; A United Nations Study. Boston: D. Reidel Publishing Company, 1979.

Gujarati, Damodar. "Use of Dummy Variables in Testing for Equality between Sets of Coefficients in Two Linear Regressions: A Note, "The American Statistician, February 1970, Vol. 24, No. 1, pages 50-52.

Gujarati, Damodar. "Use of Dummy Variables in Testing for Equality between Sets of Coefficients in Linear Regressions: A Generalization, "The American Statistician, December 1970, Vol. 24, No. 5, pages 18-22.

Hwa, E.C. "Price Determination in Several International Primary Commodity Markets: A Structural Analysis," International Monetary Fund Staff Papers, Washington, D.C., March 1979, Vol. 26, No. 1, pages 157-188.

Kmenta, Jan. Elements of Econometrics, New York. Macmillan Publishing Company, Inc., 1971.

Labys, Walter C., ed. Quantitative Models of Commodity Markets. Cambridge, Mass.: Ballinger Publishing Company, 1975.

Labys, Walter C. and Granger, Clive W.J. Speculation, Hedging and Commodity Price Forecasts. Lexington, Mass.: Heath Lexington Books, D.C. Heath and Company, 1970.

Metal Bulletin Books, Ltd. Non-Ferrous Metal Works of the World, First Edition. London, 1967.

Metal Bulletin Ltd. Metal Bulletin Handbook 1980, Surrey, U.K., 1980.

Metallgesellschaft Ag. Metal Statistics 1969-1979. Frankfurt Am Main, 1980.

McCallum, B.T. "Competitive Price Adjustments: An Empirical Study," American Economic Review, March 1974, Vol. 64., pages 56-65.

McNicol, David L. "The Two Price Systems in the Copper Industry," The Bell Journal of Economics and Management Science, Spring 1975, Vol. 6, No. 1, pages 50-73.

Mikesell, Raymond F., ed. The World Copper Industry. Baltimore: The Johns Hopkins University Press, 1979.

Muth, John F. "Rational Expectations and the Theory of Price Movements," Econometrica, July 1961, Vol. 29, No. 3, pages 315-335.

Navin, Thomas R. Copper Mining and Management. Tucson: University of Arizona Press, 1978.

Prain, Sir Ronald. Copper, The Anatomy of an Industry. London: Mining Journal Books Limited, 1975.

Rao, Potluri, and Miller, Roger. Applied Econometrics. Belmont, Calif.: Wadsworth Publishing Company, Inc., 1971.

Teweles, Richard J.; Harlow, Charles V.; and Stone, Herbert L. The Commodity Futures Game. New York, McGraw-Hill, Inc., 1969; reprint ed., 1977.

The Aluminum Association, Inc. Aluminum Statistical Review, 1979.

Working, Holbrook. "The Theory of Price of Storage," American Economic Review, December 1949, Vol. 39, pages 1254-1262.

Appendix 1

THE DATA

The data used in the econometric analysis have been described in Table 6-1. The data are tabulated in this appendix on the basis of computer nomenclature and in the order in which they appear in Table 6-1. For data originally expressed in nominal terms and which have been converted to real terms for use in the econometric analysis, we have first tabulated the data expressed in real terms followed by the same data expressed in nominal terms.

EXPRTS

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	15.9	15.6	12.8	17.7	13.5	18.3
	19.7	18.4	16.2	15.9	13.6	11.9
1974	8.2	13.1	9.5	10.0	19.8	12.4
	6.9	7.0	6.9	8.2	13.3	11.3
1975	19.7	20.8	14.3	24.9	21.3	13.5
	9.8	6.7	11.5	12.5	9.0	8.4
1976	11.2	8.5	10.8	10.9	8.6	9.4
	8.7	9.4	10.0	11.5	7.3	6.8
1977	3.7	1.8	3.6	5.2	5.2	5.2
	5.5	1.6	4.4	4.6	5.0	6.9
1978	4.7	4.9	11.9	7.3	11.4	10.1
	7.2	10.2	22.2	5.3	5.3	8.8
1979	10.8	10.3	12.8	11.0	9.8	9.6
	5.3	3.2	3.2	3.0	8.1	1.7
1980	1.1	1.6	2.1	1.6	1.6	2.2
	2.1	1.0	0.4	0.6	1.1	3.8
1981	2.9	2.5	5.8	1.2	0.9	3.5
	1.3	1.7	3.0	0.7	2.1	1.8

IMPRTS

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	21.3	18.2	21.5	12.7	16.2	10.4
	12.2	8.0	10.2	17.1	30.3	21.7
1974	23.8	25.5	33.8	19.9	26.2	22.9
	20.5	30.9	35.2	31.5	28.3	15.1
1975	14.9	11.3	3.8	2.6	2.8	13.1
	2.9	8.4	21.0	25.3	19.1	21.4
1976	21.5	33.5	26.6	48.7	45.8	38.5
	66.6	22.1	13.5	30.2	10.4	26.8
1977	26.8	21.7	17.7	35.0	28.6	36.0
	40.4	39.7	31.7	32.1	28.6	55.8
1978	47.4	45.9	58.2	77.9	47.8	53.4
	39.2	28.7	17.6	27.8	12.3	6.6
1979	12.3	7.7	17.3	16.4	16.2	25.5
	19.0	30.9	22.4	19.3	25.6	27.6
1980	3.2	41.7	58.6	35.6	41.3	30.3
	27.2	38.4	43.1	65.3	50.7	40.6
1981	24.7	29.4	21.8	28.1	21.7	34.5
	32.2	37.8	37.8	36.7	30.2	24.3

NETIMP

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	5.4	2.6	8.7	-5.0	2.7	-7.9
	-7.5	-10.4	-6.0	1.2	16.7	9.8
1974	15.6	12.4	24.3	9.9	6.4	10.5
	13.6	23.9	28.3	23.3	15.0	3.8
1975	-4.8	-9.5	-10.5	-22.3	-18.5	-0.4
	-6.9	1.7	9.5	12.8	10.1	13.0
1976	10.3	25.0	15.8	37.8	37.2	29.1
	57.9	12.7	3.5	18.7	3.1	20.0
1977	23.1	19.9	14.1	29.8	23.4	30.8
	34.9	38.1	27.3	27.5	23.6	48.9
1978	42.7	41.0	46.3	70.6	36.4	43.3
	32.0	18.5	-4.6	22.5	7.0	-2.2
1979	1.5	-2.6	4.5	5.4	6.4	15.9
	13.7	27.7	19.2	16.3	17.5	25.9
1980	2.1	40.1	56.5	34.0	39.7	28.1
	25.1	37.4	42.7	64.7	49.6	36.8
1981	21.8	26.9	16.0	26.9	20.8	31.0
	30.9	36.1	34.8	36.0	28.1	22.5

INVREF

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	142.6	140.4	126.1	97.2	95.0	82.2
	72.0	71.5	63.1	55.3	36.3	49.1
1974	49.9	43.8	57.5	66.5	61.1	39.8
	42.9	54.8	61.5	89.4	135.7	194.9
1975	242.7	259.2	297.9	320.6	334.6	338.2
	349.5	341.8	312.3	314.9	324.7	360.7
1976	363.4	370.9	347.8	343.0	325.2	317.1
	350.4	355.8	356.1	372.8	416.5	473.8
1977	469.3	487.0	472.3	442.1	447.6	435.0
	408.9	370.6	409.4	418.0	456.9	471.1
1978	488.7	491.6	470.2	480.5	465.5	464.0
	430.9	418.0	405.9	416.4	408.9	367.9
1979	318.4	287.5	262.1	237.4	197.8	176.0
	174.6	158.0	154.6	148.6	167.3	186.3
1980	203.3	228.2	237.1	269.1	277.3	295.7
	310.6	301.0	274.6	265.0	246.0	253.0
1981	261.6	249.4	236.8	245.5	243.4	264.7
	276.9	276.0	275.5	281.6	301.2	338.6

DPRCOM

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973						59.7385
	67.7295	66.7798	65.9130	70.4088	74.7388	73.6267
1974	67.9224	75.6126	85.5763	90.8864	85.2070	71.4820
	58.5900	53.0536	41.9823	39.2196	38.4838	34.9416
1975	32.6560	34.6028	37.1739	36.1875	34.2240	32.5950
	34.5952	35.5116	33.7120	32.3680	32.3680	31.8441
1976	32.7376	33.7365	36.4735	41.0256	40.8280	41.5834
	43.9663	40.7484	38.6760	33.8723	33.8720	34.1550
1977	36.6011	37.0730	39.2411	36.6704	35.1870	33.4616
	31.4088	29.3664	30.3050	30.4640	29.8100	31.6932
1978	31.3510	30.1608	30.9994	31.1112	31.2872	31.3026
	31.2120	32.8062	32.7522	33.7674	32.8342	33.5426
1979	35.4536	41.5484	43.5936	43.6106	39.5169	38.8440
	37.6882	40.2500	41.5401	41.2550	42.7856	44.9388
1980	49.9590	54.1406	40.5741	36.7157	36.7023	35.5776
	39.1777	36.9742	37.0140	36.7304	35.8020	32.5593
1981	32.2869	30.8180	31.0200	30.6528	29.5316	28.6750
	28.2624	29.6240	28.4096	27.3750	26.7540	26.6442

PRCOM

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973						76.1
	86.5	88.1	86.5	92.4	98.6	98.3
1974	93.3	105.9	120.7	129.1	122.6	103.0
	86.8	79.9	63.9	60.9	60.7	55.2
1975	52.0	55.1	59.1	57.9	55.2	53.0
	56.9	58.6	56.0	54.4	54.4	53.7
1976	55.3	56.7	61.3	69.3	69.2	70.6
	74.9	69.3	66.0	58.3	58.4	59.4
1977	64.1	65.5	69.7	65.6	63.4	60.4
	56.9	53.2	55.1	56.0	55.0	58.8
1978	58.6	56.8	58.6	59.6	60.4	60.9
	61.2	64.2	64.6	67.4	65.8	67.9
1979	72.8	86.2	91.2	92.2	83.9	83.0
	81.4	87.5	91.7	92.5	96.8	102.6
1980	117.0	128.6	97.3	88.9	89.3	87.2
	97.7	92.9	93.0	93.7	91.8	83.7
1981	84.3	81.1	82.5	82.4	79.6	77.5
	76.8	80.5	77.2	75.0	73.5	73.4

DPRTWO

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	60.8608	66.9018	76.2884	83.4240	79.4385	68.0120
	58.7925	53.3192	42.7050	39.9280	39.2446	35.7645
1975	33.0956	35.1052	37.6142	36.6875	34.5960	33.0255
	34.9600	36.2994	34.4946	32.7845	32.5465	32.3185
1976	33.0928	34.0935	36.8900	41.6768	41.2410	42.1135
	44.4946	41.0424	39.3792	34.2209	34.2780	34.7300
1977	37.0579	37.6956	39.5789	36.8381	35.5755	34.0156
	31.7400	29.7528	30.6350	30.8448	30.1894	32.0166
1978	31.7255	30.5856	31.4226	31.5810	31.7534	31.8166
	31.7220	33.2661	33.2592	34.3185	33.4330	34.1354
1979	35.9406	41.8858	44.1194	43.9890	40.0350	39.0312
	37.8271	40.5720	41.8119	42.0578	42.7856	44.4570
1980	50.8984	55.4036	41.7000	37.6656	37.2777	36.0672
	39.6589	37.3722	37.6508	37.3576	36.4650	33.4151
1981	33.0912	31.6160	31.6592	31.3596	30.3107	29.4150
	28.9616	30.3968	29.0720	27.9590	27.2636	27.1161

PRTWO

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	83.6	93.7	107.6	118.5	114.3	98.0
	87.1	80.3	65.0	62.0	61.9	56.5
1975	52.7	55.9	59.8	58.7	55.8	53.7
	57.5	59.9	57.3	55.1	54.7	54.5
1976	55.9	57.3	62.0	70.4	69.9	71.5
	75.8	69.8	67.2	58.9	59.1	60.4
1977	64.9	66.6	70.3	65.9	64.1	61.4
	57.5	53.9	55.7	56.7	55.7	59.4
1978	59.3	57.6	59.4	60.5	61.3	61.9
	62.2	65.1	65.6	68.5	67.0	69.1
1979	73.8	86.9	92.3	93.0	85.0	83.4
	81.7	88.2	92.3	94.3	96.8	101.5
1980	119.2	131.6	100.0	91.2	90.7	88.4
	98.9	93.9	94.6	95.3	93.5	85.9
1981	86.4	83.2	84.2	84.3	81.7	79.5
	78.7	82.6	79.0	76.6	74.9	74.7

DFRTHR

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	58.3856	62.6892	71.7508	79.5520	76.1025	65.5830
	59.0625	54.7136	45.8586	43.4056	43.7460	39.8157
1975	36.9264	38.3080	40.8221	40.3750	37.8820	36.1620
	38.1216	39.6930	37.8658	35.9380	35.5215	34.9277
1976	35.2240	36.4140	39.2105	43.0976	43.3650	45.0585
	47.4296	44.2764	42.1334	36.7773	37.1780	37.0875
1977	39.3990	40.0162	41.9998	39.4095	37.9620	36.0100
	34.2792	32.4576	33.0550	33.1296	32.9536	34.4421
1978	34.2400	32.9220	34.0147	33.9822	34.4470	34.7464
	34.5270	35.9744	35.5407	36.6231	36.3771	36.8030
1979	38.0347	41.9340	44.5974	44.0836	41.0241	39.8268
	38.3827	41.2160	42.7632	42.8606	43.2276	44.3256
1980	52.3929	57.9296	46.3287	40.9696	39.9492	38.9232
	41.4233	39.5214	40.7950	40.2584	40.0530	37.1106
1981	35.8488	35.5680	35.5320	35.2656	34.6514	33.1520
	33.1200	34.5184	33.0464	31.0980	29.8116	30.0927

FRTHR

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	80.2	87.8	101.2	113.0	109.5	94.5
	87.5	82.4	69.8	67.4	69.0	62.9
1975	58.8	61.0	64.9	64.6	61.1	58.8
	62.7	65.5	62.9	60.4	59.7	58.9
1976	59.5	61.2	65.9	72.8	73.5	76.5
	80.8	75.3	71.9	63.3	64.1	64.5
1977	69.0	70.7	74.6	70.5	68.4	65.0
	62.1	58.8	60.1	60.9	60.8	63.9
1978	64.0	62.0	64.3	65.1	66.5	67.6
	67.7	70.4	70.1	73.1	72.9	74.5
1979	78.1	87.0	93.3	93.2	87.1	85.1
	82.9	89.6	94.4	96.1	97.8	101.2
1980	122.7	137.6	111.1	99.2	97.2	95.4
	103.3	99.3	102.5	102.7	102.7	95.4
1981	93.6	93.6	94.5	94.8	93.4	89.6
	90.0	93.8	89.8	85.2	81.9	82.9

DPRODP

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	42.7868	43.9824	47.4784	47.4215	47.1240	46.7075
	46.5885	45.1010	45.3390	45.3390	45.1010	49.2093
1974	49.5768	48.5520	48.2120	47.8720	56.1560	59.4064
	58.0500	57.1040	54.5310	50.1032	47.9304	46.1457
1975	42.9552	39.9408	40.0044	39.7500	39.1840	38.4375
	37.6352	38.2992	38.0464	37.6040	37.6040	37.4776
1976	37.2960	37.4850	38.1395	40.6112	41.3000	41.2300
	43.4380	43.3356	43.1882	41.3672	40.4260	37.3175
1977	37.2863	38.3182	40.3671	41.0865	39.7935	38.8908
	36.9840	34.6656	32.7800	32.4224	32.3032	32.8251
1978	33.4910	33.2406	32.4806	33.1992	33.0484	33.7184
	32.1810	33.8282	33.7662	34.8195	35.0298	35.0246
1979	36.8172	42.7534	45.7446	46.0229	42.4842	40.8096
	39.7254	41.5380	42.9897	43.7526	43.6254	46.1652
1980	50.5568	55.9088	43.7850	38.7807	38.0175	37.4136
	41.1426	39.6806	38.9642	38.6120	37.4400	34.2709
1981	33.5125	32.1860	32.3360	32.2152	31.3124	31.0060
	30.5440	31.6480	30.6544	29.5285	29.0472	28.6407
1982	27.5040	27.7920	27.9414			

PRODP

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	51.8	53.9	59.2	59.5	59.5	59.5
	59.5	59.5	59.5	59.5	59.5	65.7
1974	68.1	68.0	68.0	68.0	80.8	85.6
	86.0	86.0	83.0	77.8	75.6	72.9
1975	68.4	63.6	63.6	63.6	63.2	62.5
	61.9	63.2	63.2	63.2	63.2	63.2
1976	63.0	63.0	64.1	68.6	70.0	70.0
	74.0	73.7	73.7	71.2	69.7	64.9
1977	65.3	67.7	71.7	73.5	71.7	70.2
	67.0	62.8	59.6	59.6	59.6	60.9
1978	62.6	62.6	61.4	63.6	63.8	65.6
	63.1	66.2	66.6	69.5	70.2	70.9
1979	75.6	88.7	95.7	97.3	90.2	87.2
	85.8	90.3	94.9	98.1	98.7	105.4
1980	118.4	132.8	105.0	93.9	92.5	91.7
	102.6	99.7	97.9	98.5	96.0	88.1
1981	87.5	84.7	86.0	86.6	84.4	83.8
	83.0	86.0	83.3	80.9	79.8	78.9
1982	76.4	77.2	77.4			

DSCRPR

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	34.7746	37.1280	41.9446	44.0741	43.8768	46.4720
	46.9800	49.8006	51.8160	55.1688	58.4418	52.7296
1974	48.9944	50.9796	67.1423	71.5968	66.6505	52.3970
	43.9425	42.4296	31.7988	29.2376	27.8960	25.2567
1975	23.5500	25.2456	27.7389	27.1875	25.2960	23.6775
	25.4144	26.9670	25.4646	24.3355	23.6215	23.5421
1976	24.2128	24.6330	27.4295	30.6656	30.8570	31.6293
	33.8699	31.1640	28.8312	23.9372	24.3600	24.9550
1977	27.5793	28.1868	30.1768	27.8382	26.4180	24.8746
	22.6320	20.9208	21.2850	21.3792	20.9754	23.0692
1978	25.4660	24.4260	25.0217	25.5258	25.6928	25.6486
	25.5000	26.7764	26.8203	27.5049	26.8462	27.1700
1979	28.9278	34.2702	36.3758	36.7521	33.1113	31.6836
	30.6506	32.4760	33.2955	32.3796	32.9290	31.4922
1980	37.4479	40.7528	30.3159	28.0014	28.1124	27.9072
	30.7166	29.0540	28.8152	28.6552	28.0020	25.2461
1981	25.2014	24.8140	25.4176	25.4820	24.7086	24.0870
	23.6624	24.2144	23.0736	22.3380	21.7672	21.3444

SCRPR

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	42.1	45.5	52.3	55.3	55.4	59.2
	60.0	65.7	68.0	72.4	77.1	70.4
1974	67.3	71.4	94.7	101.7	95.9	75.5
	65.1	63.9	48.4	45.4	44.0	39.9
1975	37.5	40.2	44.1	43.5	40.8	38.5
	41.8	44.5	42.3	40.9	39.7	39.7
1976	40.9	41.4	46.1	51.8	52.3	53.7
	57.7	53.0	49.2	41.2	42.0	43.4
1977	48.3	49.8	53.6	49.8	47.6	44.9
	41.0	37.9	38.7	39.3	38.7	42.8
1978	47.6	46.0	47.3	48.9	49.6	49.9
	50.0	52.4	52.9	54.9	53.9	55.0
1979	59.4	71.1	76.1	77.7	70.3	67.7
	66.2	70.6	73.5	72.6	74.5	71.9
1980	87.7	96.8	72.7	67.8	68.4	68.4
	76.6	73.0	72.4	73.1	71.8	64.9
1981	65.8	65.3	67.6	68.5	66.6	65.1
	64.3	65.8	62.7	61.2	59.8	58.8

PRIMPD

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	147.1	138.3	145.0	149.5	150.9	147.5
	99.7	75.6	121.3	165.6	148.6	139.7
1975	148.6	129.0	128.4	125.7	127.3	120.2
	105.9	111.0	104.3	116.4	106.4	118.7
1976	114.3	106.2	136.5	133.3	124.8	133.9
	111.8	128.9	143.7	134.8	133.0	136.0
1977	125.5	123.6	169.6	166.2	166.9	176.9
	46.2	69.1	88.5	118.2	125.2	120.2
1978	116.3	116.0	134.6	119.8	129.6	128.4
	104.8	133.6	123.4	136.4	147.4	142.8
1979	136.2	140.3	147.0	148.0	147.8	137.8
	128.7	145.6	115.0	138.5	145.7	139.7
1980	146.5	141.2	146.7	160.2	178.9	171.0
	49.4	25.0	28.4	70.8	99.4	133.5
1981	138.9	137.8	153.9	154.4	145.2	146.7
	133.2	121.6	134.3	142.1	125.0	143.5
1982	117.1					

SECPD

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974				44.0	50.0	46.0
	34.0	35.0	37.0	41.0	33.0	33.0
1975	30.0	28.0	27.0	29.0	24.0	25.0
	23.0	28.0	32.0	29.0	28.0	30.0
1976	31.0	29.0	28.0	29.0	31.0	28.0
	24.0	26.0	30.0	26.0	41.0	30.0
1977	30.0	31.0	32.0	36.0	39.0	46.0
	24.0	21.0	25.0	26.0	26.0	28.0
1978	29.0	31.0	41.0	41.0	41.0	44.0
	30.0	36.0	37.0	41.0	39.0	43.0
1979	45.4	41.4	54.1	54.0	52.4	58.1
	47.1	55.3	54.0	60.8	61.3	50.5
1980	70.7	61.9	61.5	58.4	60.7	58.1
	29.3	37.0	36.8	67.0	49.6	40.7
1981	42.9	58.2	50.2	69.6	61.4	67.8
	60.0	64.4	55.3	64.8	35.8	66.2
1982	52.4					

DMFRC

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	3.95654	3.90864	3.87366	3.84154	3.84120	3.89360
	3.93849	3.82032	3.88620	3.90144	3.90370	3.90978
1974	3.79288	3.79134	3.84987	3.87200	3.81555	3.87946
	3.83400	3.82464	3.83031	3.77384	3.72158	3.75369
1975	3.74916	3.74288	3.79916	3.77500	3.76340	3.84375
	3.85472	3.87840	3.90698	3.88535	3.87940	3.81892
1976	3.87168	3.87940	3.95080	3.99008	3.95890	4.01698
	4.05617	4.09248	4.14302	4.12510	4.16440	4.12850
1977	4.08836	4.07520	4.07612	4.10306	4.09035	4.27134
	4.32216	4.29456	4.40550	4.39008	4.40104	4.39285
1978	4.40840	4.39668	4.37483	4.34304	4.33048	4.39984
	4.39620	4.42526	4.43118	4.42383	4.42114	4.43118
1979	4.38300	4.34282	4.35458	4.48877	4.30494	4.41792
	4.43091	4.46200	4.43487	4.40202	4.35812	4.34496
1980	4.29562	4.21842	4.27008	4.25803	4.26618	4.36560
	4.34283	4.29442	4.35810	4.31592	4.31730	4.40348
1981	4.33556	4.31680	4.32776	4.33008	4.33699	4.40300
	4.49328	4.45280	4.67360	4.54060	4.54272	4.51935
1982	4.55760	4.53960				

MFRC

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	4.79	4.79	4.83	4.82	4.85	4.96
	5.03	5.04	5.10	5.12	5.15	5.22
1974	5.21	5.31	5.43	5.50	5.49	5.59
	5.68	5.76	5.83	5.86	5.87	5.93
1975	5.97	5.96	6.04	6.04	6.07	6.25
	6.34	6.40	6.49	6.53	6.52	6.44
1976	6.54	6.52	6.64	6.74	6.71	6.82
	6.91	6.96	7.07	7.10	7.18	7.18
1977	7.16	7.20	7.24	7.34	7.37	7.71
	7.83	7.78	8.01	8.07	8.12	8.15
1978	8.24	8.28	8.27	8.32	8.36	8.56
	8.62	8.66	8.74	8.83	8.86	8.97
1979	9.00	9.01	9.11	9.49	9.14	9.44
	9.57	9.70	9.79	9.87	9.86	9.92
1980	10.06	10.02	10.24	10.31	10.38	10.70
	10.83	10.79	10.95	11.01	11.07	11.32
1981	11.32	11.36	11.51	11.64	11.69	11.90
	12.21	12.10	12.70	12.44	12.48	12.45
1982	12.66	12.61				

INDMATPR

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	128.0	133.3	133.5	133.5	134.2	136.3
	129.2	133.9	135.8	137.5	137.1	134.5
1974	133.0	136.3	136.6	134.3	136.7	138.4
	128.8	132.9	135.7	134.3	125.9	115.9
1975	112.2	111.8	110.0	110.2	110.9	114.6
	109.2	117.5	121.4	123.5	123.5	121.3
1976	124.0	130.4	131.8	131.7	133.4	135.5
	127.1	133.0	133.8	134.5	133.9	131.3
1977	131.0	136.1	139.1	139.4	140.8	142.5
	134.0	137.9	139.9	142.3	141.3	138.2
1978	138.5	142.3	143.9	147.8	148.5	151.5
	143.8	148.6	151.7	154.8	154.5	153.5
1979	151.6	156.9	158.8	156.8	157.6	159.9
	151.9	155.1	156.9	158.3	156.6	153.9
1980	153.9	157.9	158.3	152.9	145.6	143.0
	131.7	138.1	143.2	147.3	150.3	149.6
1981	150.4	155.4	156.7	154.5	155.1	157.2
	150.2	154.3	153.2	150.1	144.8	136.8

DPRLME

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	41.9608	45.9408	55.1776	57.3840	55.8360	62.2505
	71.7228	71.8584	66.9798	71.3994	77.9982	75.6490
1974	66.9760	74.1132	88.4832	96.8704	90.6280	76.8258
	58.7250	54.2488	43.4934	40.8940	40.7028	37.0305
1975	34.4772	36.1100	38.3061	37.6875	35.2780	33.2715
	33.6832	35.1480	33.0498	31.8325	31.8325	30.9546
1976	32.0272	32.9035	35.8785	40.5520	40.4740	41.4067
	43.8489	40.9836	38.8518	33.8723	33.5820	33.5800
1977	36.1443	36.5636	38.6781	36.2232	34.5210	32.9630
	31.2432	29.0352	29.8100	29.8656	29.0512	30.7769
1978	30.6020	29.3112	30.1001	30.4326	30.5620	31.0456
	30.9060	33.0617	33.1578	34.2183	33.2833	34.3330
1979	36.6224	42.5124	44.4062	45.0296	41.1183	39.8736
	38.0586	41.2160	43.0803	41.9686	41.8574	43.9752
1980	50.3433	53.3828	43.6182	38.9046	38.1819	37.1280
	39.5787	37.5712	37.1732	36.3776	35.6070	33.1428
1981	32.4784	31.0460	31.0200	30.7644	29.3090	28.5270
	28.0784	29.8080	28.5568	27.5940	27.2636	27.2613
1982	26.2800	26.0640	24.7285	24.9090		

PRLME

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	50.8	56.3	68.8	72.0	70.5	79.3
	91.6	94.8	87.9	93.7	102.9	101.0
1974	92.0	103.8	124.8	137.6	130.4	110.7
	87.0	81.7	66.2	63.5	64.2	58.5
1975	54.9	57.5	60.9	60.3	56.9	54.1
	55.4	58.0	54.9	53.5	53.5	52.2
1976	54.1	55.3	60.3	68.5	68.6	70.3
	74.7	69.7	66.3	58.3	57.9	58.4
1977	63.3	64.6	68.7	64.8	62.2	59.5
	56.6	52.6	54.2	54.9	53.6	57.1
1978	57.2	55.2	56.9	58.3	59.0	60.4
	60.6	64.7	65.4	68.3	66.7	69.5
1979	75.2	88.2	92.9	95.2	87.3	85.2
	82.2	89.6	95.1	94.1	94.7	100.4
1980	117.9	126.8	104.6	94.2	92.9	91.0
	98.7	94.4	93.4	92.8	91.3	85.2
1981	84.8	81.7	82.5	82.7	79.0	77.1
	76.3	81.0	77.6	75.6	74.9	75.1
1982	73.0	72.4	68.5	69.0		

DPRAL

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	19.9472	20.0634	22.1208	24.1472	24.1165	23.8042
	23.2875	25.5640	24.9660	24.6652	24.2188	24.6870
1975	25.4968	25.8736	26.1664	25.4375	25.4200	25.2150
	23.8336	23.0280	22.5750	22.0150	21.8960	22.5340
1976	22.9104	22.9670	22.0150	22.0224	22.0660	21.4985
	24.0083	25.0488	26.4872	24.9830	24.9400	25.4150
1977	27.4080	27.6774	27.6433	27.4469	27.2505	27.7000
	29.3112	29.6424	29.5900	29.7024	30.4062	30.8308
1978	31.9395	31.8069	31.1581	29.8062	29.0598	29.1438
	29.7840	30.6089	31.7889	32.3646	31.5368	31.5666
1979	31.4602	31.1372	31.3568	31.5491	31.2273	32.7600
	34.6324	34.0860	32.9784	32.6026	32.7080	33.4632
1980	34.2027	35.4482	33.9021	33.7008	34.8939	35.1288
	35.0474	34.7852	35.2230	34.9272	34.4370	33.6485
1981	33.9338	32.1100	30.9448	29.8716	28.5299	26.9360
	25.4288	25.4288	24.6192	24.7835	25.5164	25.4826

PRAL

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	27.4	28.1	31.2	34.3	34.7	34.3
	34.5	38.5	38.0	38.3	38.2	39.0
1975	40.6	41.2	41.6	40.7	41.0	41.0
	39.2	38.0	37.5	37.0	36.8	38.0
1976	38.7	38.6	37.0	37.2	37.4	36.5
	40.9	42.6	45.2	43.0	43.0	44.2
1977	48.0	48.9	49.1	49.1	49.1	50.0
	53.1	53.7	53.8	54.6	56.1	57.2
1978	59.7	59.9	58.9	57.1	56.1	56.7
	58.4	59.9	62.7	64.6	63.2	63.9
1979	64.6	64.6	65.6	66.7	66.3	70.0
	74.8	74.1	72.8	73.1	74.0	76.4
1980	80.1	84.2	81.3	81.6	84.9	86.1
	87.4	87.4	88.5	89.1	88.3	86.5
1981	88.6	84.5	82.3	80.3	76.9	72.8
	69.1	69.1	66.9	67.9	70.1	70.2

DELIV

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	171.2	162.0	180.0	204.5	211.1	193.5
	138.4	116.6	150.1	161.3	129.4	92.8
1975	99.3	84.3	94.2	95.8	115.0	118.2
	110.5	127.0	137.5	131.2	117.2	115.7
1976	137.9	132.7	206.2	175.5	171.7	158.6
	150.6	134.5	151.0	150.6	122.6	137.4
1977	166.6	138.2	202.0	195.6	185.3	192.4
	104.5	100.6	100.5	145.7	135.9	141.0
1978	137.7	141.3	190.2	148.7	175.9	159.8
	133.4	168.9	179.2	170.4	177.7	179.7
1979	191.1	174.8	193.5	182.4	204.7	192.4
	166.4	179.3	157.4	190.4	161.4	156.7
1980	173.5	153.7	193.5	167.8	176.3	175.0
	98.7	85.0	83.7	106.6	128.7	154.5
1981	152.8	154.4	196.4	164.7	168.3	158.7
	150.2	153.4	157.6	159.5	128.6	131.0

PRIDF

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1973	0.826	0.816	0.802	0.797	0.792	0.785
	0.783	0.758	0.762	0.762	0.758	0.749
1974	0.728	0.714	0.709	0.704	0.695	0.694
	0.675	0.664	0.657	0.644	0.634	0.633
1975	0.628	0.628	0.629	0.625	0.620	0.615
	0.608	0.606	0.602	0.595	0.595	0.593
1976	0.592	0.595	0.595	0.592	0.590	0.589
	0.587	0.588	0.586	0.581	0.580	0.575
1977	0.571	0.566	0.563	0.559	0.555	0.554
	0.552	0.552	0.550	0.544	0.542	0.539
1978	0.535	0.531	0.529	0.522	0.518	0.514
	0.510	0.511	0.507	0.501	0.499	0.494
1979	0.487	0.482	0.478	0.473	0.471	0.468
	0.463	0.460	0.453	0.446	0.442	0.438
1980	0.427	0.421	0.417	0.413	0.411	0.408
	0.401	0.398	0.398	0.392	0.390	0.389
1981	0.383	0.380	0.376	0.372	0.371	0.370
	0.368	0.368	0.368	0.365	0.364	0.363
1982	0.360	0.360	0.361	0.361	0.360	0.357

DPRCHTWO

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	-7.0616	-8.7108	-9.2879	-7.4624	-5.7685	-3.4700
	0.2025	0.2656	0.7227	0.7084	0.7608	0.8229
1975	0.4396	0.5024	0.4403	0.5000	0.3720	0.4305
	0.3648	0.7878	0.7826	0.4165	0.1785	0.4744
1976	0.3552	0.3570	0.4165	0.6512	0.4130	0.5301
	0.5283	0.2940	0.7032	0.3486	0.4060	0.5750
1977	0.4568	0.6226	0.3378	0.1677	0.3885	0.5540
	0.3312	0.3864	0.3300	0.3808	0.3794	0.3234
1978	0.3745	0.4248	0.4232	0.4698	0.4662	0.5140
	0.5100	0.4599	0.5070	0.5511	0.5988	0.5928
1979	0.4870	0.3374	0.5258	0.3784	0.5181	0.1872
	0.1389	0.3220	0.2718	0.8028	0.0000	-0.4818
1980	0.9394	1.2630	1.1259	0.9499	0.5754	0.4896
	0.4812	0.3980	0.6368	0.6272	0.6630	0.8558
1981	0.8043	0.7980	0.6392	0.7068	0.7791	0.7400
	0.6992	0.7728	0.6624	0.5840	0.5096	0.4719

DCHPRDN

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	0.0000	-8.9964	-10.4932	-5.9136	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1975	0.0000	-1.9468	-2.5160	0.0000	0.0000	0.0000
	-2.3712	-1.0302	0.0000	0.0000	0.0000	0.0000
1976	-0.9472	-0.8330	-2.7370	-4.7360	0.0000	-0.8246
	-2.5241	0.0000	0.0000	0.0000	-0.0580	-0.5750
1977	-2.6837	-0.7924	-2.3646	0.0000	0.0000	0.0000
	0.0000	0.0000	-1.0450	-0.4896	0.0000	-2.0482
1978	0.0000	0.0000	-0.9522	-0.5220	-0.4144	-0.2570
	-0.1530	-1.5330	-0.2028	-1.4028	0.0000	-1.0374
1979	-2.3863	-6.4588	-2.3900	-0.4730	0.0000	0.0000
	0.0000	-2.8060	-1.9026	-0.3568	-1.9006	-2.5404
1980	-6.1488	-4.8836	0.0000	0.0000	-0.1644	0.0000
	-4.2105	0.0000	-0.0398	-0.2744	0.0000	0.0000
1981	-0.2298	0.0000	-0.5264	0.0000	0.0000	0.0000
	0.0000	-1.3616	0.0000	0.0000	0.0000	0.0000

DCHFRSN

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	3.6400	0.0000	0.0000	0.0000	4.5175	13.6024
	10.9350	4.5816	10.5120	1.9320	0.1268	3.4815
1975	2.0096	0.0000	0.0000	0.7500	1.6740	1.3530
	0.0000	0.0000	1.5652	0.9520	0.0000	0.4151
1976	0.0000	0.0000	0.0000	0.0000	0.0590	0.0000
	0.0000	3.2928	1.9338	4.4737	0.0000	0.0000
1977	0.0000	0.0000	0.0000	2.2919	1.2210	1.6620
	1.9320	2.0424	0.0000	0.0000	0.5420	0.0000
1978	0.1070	0.9558	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.7984	0.0000
1979	0.0000	0.0000	0.0000	0.0000	3.9093	0.4212
	0.7408	0.0000	0.0000	0.0000	0.0000	0.0000
1980	0.0000	0.0000	13.0521	3.4692	0.0000	0.8568
	0.0000	1.9104	0.0000	0.0000	0.7410	3.1509
1981	0.0000	1.2160	0.0000	0.0372	1.0388	0.7770
	0.2576	0.0000	1.2144	0.8030	0.5460	0.0363

LABUNR

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	0	0	0	0	0	0
	1	1	0	0	0	0
1975	0	0	0	0	0	0
	0	0	0	0	0	0
1976	0	0	0	0	0	0
	0	0	0	0	0	0
1977	0	0	0	0	0	0
	1	1	1	0	0	0
1978	0	0	0	0	0	0
	0	0	0	0	0	0
1979	0	0	0	0	0	0
	0	0	0	0	0	0
1980	0	0	0	0	0	0
	1	1	1	1	1	0
1981	0	0	0	0	0	0
	0	0	0	0	0	0

SONE

	JAN	FEB	MAR	APR	MAY	JUN
	JUL	AUG	SEP	OCT	NOV	DEC
1974	1	1	1	0	0	0
	0	0	0	0	0	0
1975	1	1	1	0	0	0
	0	0	0	0	0	0
1976	1	1	1	0	0	0
	0	0	0	0	0	0
1977	1	1	1	0	0	0
	0	0	0	0	0	0
1978	1	1	1	0	0	0
	0	0	0	0	0	0
1979	1	1	1	0	0	0
	0	0	0	0	0	0
1980	1	1	1	0	0	0
	0	0	0	0	0	0
1981	1	1	1	0	0	0
	0	0	0	0	0	0

STWO

	JAN	FEB	MAR	APR	MAY	JUN
	JUL	AUG	SEP	OCT	NOV	DEC
1974	0	0	0	1	1	1
	0	0	0	0	0	0
1975	0	0	0	1	1	1
	0	0	0	0	0	0
1976	0	0	0	1	1	1
	0	0	0	0	0	0
1977	0	0	0	1	1	1
	0	0	0	0	0	0
1978	0	0	0	1	1	1
	0	0	0	0	0	0
1979	0	0	0	1	1	1
	0	0	0	0	0	0
1980	0	0	0	1	1	1
	0	0	0	0	0	0
1981	0	0	0	1	1	1
	0	0	0	0	0	0

STHR

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	0	0	0	0	0	0
	1	1	1	0	0	0
1975	0	0	0	0	0	0
	1	1	1	0	0	0
1976	0	0	0	0	0	0
	1	1	1	0	0	0
1977	0	0	0	0	0	0
	1	1	1	0	0	0
1978	0	0	0	0	0	0
	1	1	1	0	0	0
1979	0	0	0	0	0	0
	1	1	1	0	0	0
1980	0	0	0	0	0	0
	1	1	1	0	0	0
1981	0	0	0	0	0	0
	1	1	1	0	0	0

DM

	JAN JUL	FEB AUG	MAR SEP	APR OCT	MAY NOV	JUN DEC
1974	1	1	1	1	1	1
	1	1	1	1	1	1
1975	1	1	1	1	1	1
	1	1	1	1	1	1
1976	1	1	1	1	1	1
	1	1	1	1	1	1
1977	1	1	1	1	1	1
	1	1	1	1	1	1
1978	1	1	1	1	1	1
	0	0	0	0	0	0
1979	0	0	0	0	0	0
	0	0	0	0	0	0
1980	0	0	0	0	0	0
	0	0	0	0	0	0
1981	0	0	0	0	0	0
	0	0	0	0	0	0

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